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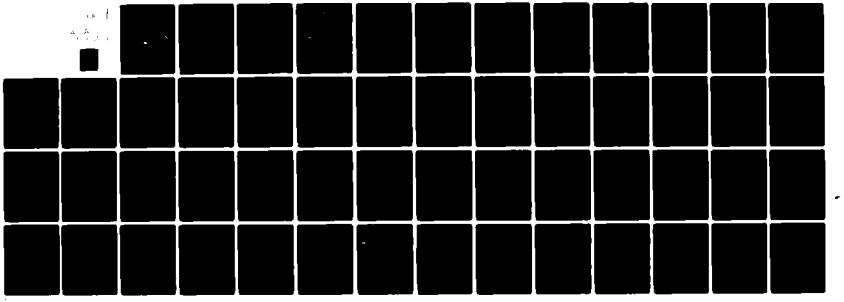

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts

The articles are written primarily by members of the staff of ONRL anc occasionally articles are prepared by, or in cooperation with, members of the

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scientific staffs of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

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ACOUSTICS

UNDERWATER ACOUSTICS AT THE UNIVERSITY OF BIRMINGHAM

The Underwater Acoustics Group in the Department of Electronic and Electrical Engineering of the University of Birmingham was formed over 20 years ago. Nine senior staff members work under the direction of Dr. D.J. Creasey.

My experience with Birmingham in the past had consisted of passing over, through, and around it a number of times on one of the busiest freeway systems in the world. The 400-acre campus of the university is like an oasis in the vast industrial complex of that city. The university has trebled in size in the past 15 years so most of the buildings I saw are new and modern with parklike surroundings.

Since its inception the Acoustics Group has been deeply involved with industry in the design and construction of a wide variety of prototype sonar instrumentation ranging from adaptations used in food processing to instruments used to scan rapidly the bottoms of supertankers for damage. In order to make the facilities and expertise of the Acoustics Group more and more widely available to industry, government organizations and other academic establishments, an industrial liaison office, the Wolfson Acoustic Unit, was recently established with funds that had been awarded to the university by the Wolfson Foundation. (This large foundation supports applied science, commerce, and education with the intent to improve the economic position of Great Britain and help to modernize British Industry.) Its full-time director, Mr. P.D. McQueen, came from the Plessey Company. The office not only serves as a link between the university and industry but also acts as an information exchange interface among various other industries. This article is concerned with the research on marine and oceanographic problems.

It is difficult for the pilots or masters of supertankers three football fields long to keep track of the relative positions of their ships to the wharfs during the process of docking. The Acoustics Group recently designed an improved side-looking sonar system that constantly informs the individual conning a vessel where the vessel is relative to the wharf.

In another effort, the group is working on acoustic methods for remote sensing and classification of bottom sediments in order to be able to survey relatively large areas in a short time. The resulting system will be used to prospect for commercial gravel deposits and possibly for mineral nodules on the sea floor. Artificial bottoms consisting of sand, lead shot, and glass marbles have been used for research in the laboratory's research tank which measures 10 m × 5 m × 3 m in depth.

Sector sonar, or as it is now called, side-scan sonar has been the subject of research at the University of Birmingham for many years. One of their systems called a "digital" sonar was purchased by the Marconi International Marine Company for fisheries research, but the company has used it instead for projects related to the offshore gas and oil industry. Dr. P.N. Denbigh is currently working on the design of a second-generation side-scan sonar that has the capability of obtaining very accurate information on bathymetry by measuring the time difference in the sensing of the return echo by two hydrophones mounted one above the other. The resulting topography can be displayed in color in real-time on a TV screen; in addition, the depth data can be run through a computer that draws depth contour lines. Denbigh is also working on methods by which the computer can be used to give correct depth information from the slant ranges that are obtained from the sonar. He has developed a stereoscopic side-scan display whose output clearly shows features on the bottom in three dimensions. This has been used to study an underwater archeological site where a ship sank and broke up many years ago. Fiber optics are used to record the two stereo images on paper, one line at a time, as the paper is drawn through the fiber optics recorder. The sonar is mounted in a towed "fish" that rolls because of wave action. This generates a spurious signal that appears on the imagery as parallel ridges and ditches. Denbigh believes that he can design a more stable fish that will eliminate the rolling. His prototype used a 400 KHz signal. The new model will use 175 KHz which will increase the effective range with some loss of definition. The biggest problem is noise from multipath returns primarily from water surface echoes. He is experimenting with baffles to mask the surface echoes.

Dr. V.G. Welsby is working on the problem of estimating populations in shoals of fish, in cooperation with researchers at the Lowestoft Fisheries Laboratory in Suffolk, UK. It turns out that multiple scattering and near forward scattering make it difficult to quantify return echoes and estimate accurately the number of fish in a shoal. The ratio of the size of the fish scattering the sound waves to the wave lengths of the sound is the same order of magnitude as the ratio of the size of fine suspended material in the ocean to the wave length

of visible light. For this reason Welsby is using equations developed for marine optics in an attempt to improve the interpretation of sonar signal returns from fish shoals.

A visiting Polish scientist, Ms. M. Brzozowska, is endeavoring to use acoustics to study the habits of a small commercial lobster that is caught in Scottish sea lochs. When caught commercially, all the lobsters under a given size limit are tossed back into the water. Some fisheries biologists doubt if the lobsters can survive after being caught and then exposed to full sunlight. Researchers have put tiny pingers and transponders on the lobsters to try to follow individuals and learn their habits. They soon found that the high frequency (300 KHz) signals they were using were absorbed in the mud when the lobsters burrowed into the bottom. Brzozowska will try using a 100 KHz signal which would normally require a much larger pinger or transducer. She is experimenting with a number of different materials in an effort to reduce the size of the sensors to about the size of a matchhead.

McQueen showed me a concurrent development consisting of a sound "flashlight" which can be handcarried by a diver or fixed to the bottom of a boat. It is used to give range and bearing of a pinger or transponder placed on a fish or crustacean. The whole unit is about the size of a pint thermos jug and does a very good job of tracking moving sound sources or transducers in shallow water.

Creasy discussed some sonar systems that were under development for the offshore oil and gas industry. One was a remote acoustic interrogator to be used to determine if cathodic protection devices were working correctly (had the proper production voltage) on sea-floor pipelines and oil drilling rigs. Each cathode package will have its own internal voltage sensing device which will respond to acoustic interrogation. A second system will use a parametric sound source for sub-bottom profiling of the top 4 to 5 m of bottom sediments in areas where sea-floor oil and gas pipe lines are to be built.

In addition to its own research programs, the group regularly does testing and calibration of acoustic devices for industry and government laboratories.

It is interesting to note that the University of Birmingham has the largest university effort in underwater acoustics in the UK and yet its location in the center of England places it farther from the ocean than any other university in the UK. (Wayne V. Burt)

CHEMISTRY

6TH ANNUAL MEETING OF THE PHOTOCHEMISTRY DIVISION OF THE GERMAN CHEMICAL SOCIETY

Goettingen

I attended the 6th Annual Meeting of the Photochemistry Division of the German Chemical Society (November 1979) and chaired the last session of this 1½ day meeting. The conference was attended by over 100 chemists, mostly from Germany, but with participants also from Switzerland, Austria, and even Sweden. As usual, each half-day session was introduced by a plenary lecture (45 minutes), and the remainder of the time was taken up by brief (15-minute) contributed papers.

The organizing committee selected three quite diverse topics for the plenary lectures: Dr. H. Tributsch (Fritz Haber Institute, Berlin) talked about "Heterogenous Photochemistry and Solar Energy Conversion via d-States in Transition Metal Compounds"; Dr. K. Schulten (MPI for Biophysical Chemistry, Goettingen) gave a talk on "Biomolecular Transformation of Light Energy"; and Prof. K. Schaffner (MPI for Coal Research, Muelheim) discussed "New Results in the Field of Organic Photochemistry." (It is interesting to note that the three plenary lectures were presented by representatives of Max-Planck Institutes!)

Tributsch described some very interesting work, part of the extensive program of the Fritz Haber Institute, that is aimed at the photochemical splitting of water into hydrogen and oxygen. In this work, they have been studying the use of transition metal chalcogenides, especially MoS_2 and PtS_2, as the covalently bound, tightly held semiconductor electrodes for this photoelectrochemical process.

They find that molybdenum compounds (disulfide or the diselenide) are useful in that, unlike the corresponding cadmium compounds, they do not yield elemental S or Se as by-products during the electrolysis, but are oxidized to sulfate or selenate, respectively. Tungsten selenide also shows great promise as the electrode when used with the redox system of I_2/I^-. They are currently starting an investigation of zirconium and hafnium compounds. They find that PtS_2 is a very effective electrode for splitting water under acidic (1N HCl) conditions. They are now looking for the chalcogenide that will duplicate the behavior of the platinum compound without being so expensive.

In his talk, Schulten (who will soon be leaving Goettingen to join the faculty of the Physics Department of the Technical

Univ. of Munich) discussed some new aspects of the photochemistry of the visual pigment rhodopsin that he isolated from halobacterium-halobium. In their work they found that the rotation about the single bonds was base-catalyzed, while the rotation about double bonds was acid-catalyzed.

In his elegant presentation, Schaffner discussed some new findings on the mechanism of the di-π-methane rearrangements. He pointed out that the triplet pathway accounts for only about half of the observed quantum yield. They established that the triplet had an energy of ca. 59 Kcal and that it phosphoresces at low temperatures. They also found evidence for biradical intermediates (τ≈10 nsec) by laser-flash spectroscopy. Schaffner suggested that some molecules may show promise for solar energy storage, since the photochemical rearrangement can be reversed thermally in an acid-catalyzed reaction.

The contributed papers were of uniformly high quality. Of special interest was a paper by W. Drews, R. Schmidt, and H.D. Brauer (Univ. of Frankfurt), describing a new photochromic system of high thermal stability resulting from the oxidation of dibenzo(aj) perylene-8, 16-dione to its endoperoxide. The oxidation occurs during excitation of the dione with visible light and the reverse reaction takes place when ultraviolet light is used. Both the dione and the endoperoxide exhibit remarkable thermal stability and the system can be recycled without any appreciable decomposition. A fluorescence spectroscopic study of micelle systems was the subject of a talk by Dr. K.A. Zachariasse (Univ. of Goettingen). In this study, they compared the fluorescence of pyrene in different solvents with the fluorescence exhibited in different micelle systems and determined the lifetime of the fluorescent species and the quenching observed in the presence of certain external ions. While most of the papers dealt with the photochemistry of organic or bio-organic species, one of the few exceptions was a paper by Prof. J. Troe (Goettingen) describing a physical chemical study of the recombination of iodine atoms in hydrocarbon solution when excited by a dye laser. They found good evidence for a "cage effect" and carried out their studies at pressures ranging from 1 to 3,000 atmospheres. (George M. Wyman, United States Army Research and Standardization Group [Europe])

COMMUNICATIONS

COMMUNICATIONS R&D AT POLITECNICO di MILANO

The Istituto di Elettrotecnica ed Elettronica (IE&E) of the Politecnico di Milano, in Milan Italy, is equivalent in breadth of interest to an American university's Department of Electrical Engineering and Computer Science. The assortment of some 50 courses offered to about 1500 students reflects the almost equal distribution of interest among the students and teaching staff in three fields: communications, computer science, and automatic control. During my recent visit to the IE&E, I concentrated on the activities of the Communications Group which is directed by Prof. Fabio Rocca, who acted as my host for the visit. Rocca is also the director of the IE&E. His particular research interests include picture coding (in general), methods for reducing the bandwidth of transmitted television signals and, as suitable combinations of the other two, the communication aspects of telemedicine and teleconferencing systems. In the picture-coding laboratory, Rocca showed me the results of some ongoing studies related to picture processing in support of medical radiology, and in particular, to emissive tomography (ET). In the ET process, the spot energy densities within many planar projections of the radiation field emitted by an ingested radiopharmaceutical are measured through a 360-degree scan of the body region being evaluated. Processing of these data results in a set of pictures or cathode-ray tube displays that are useful for medical diagnoses.

There are two basic picture processing problems in ET. First, *inaccuracies* in relative magnitudes may result because the absorption within the transmission medium (body tissues between the internal emitter and the external detection planes) is nonuniform. While this nonuniformity of absorption is precisely the parameter of interest in the more common form of tomography, transmission tomography (TT), the nonuniformity tends to mask the ET process, which is more locally oriented than is TT, and as a result it can cause undesirable loss of contrast in parts of the reconstructed ET image. The nonuniformity results from both geometric considerations (path length variations) and intermediate tissue density variations (e.g., bones vs. soft tissues).

Secondly, picture *quality* tradeoffs must be considered. High resolution implies the use of a narrow-slit collimator, which implies inefficient energy collection and therefore a low signal-to-noise ratio in the measurements. This in turn, implies

a degraded contrast in the processed output. Wider-slit collimators, on the other hand, while they improve the contrast, cause a degradation (smearing) of the detail of the reconstructed image.

Until recently, Rocca and his collaborators on this project attacked only the geometric part of the nonuniformity problem. They reported on that aspect of their work in the *IEEE Transactions on Acoustics, Speech, and Signal Processing*, Vol ASSP-27, No. 3, June 1979, pp. 213-217. In that paper, they described their method of reconstructing the image spectrum by solving a linear partial differential equation that related the true image spectrum to the spatial spectra of the absorption and measurements.

I witnessed a demonstration which reflected two modifications to the results reported above. In the first modification, pseudo-color modulation was added to the processing system. This AM-to-FM (color) transformation was said to provide somewhat better subjective contrast in the display for some medical diagnosticians. (But, I must admit that, as one with measurable color perception limitations [color-blindness—although I am not really *blind* to most color variations], I could not evaluate that feature.)

In the second modification, a deconvolution algorithm was added which, in effect, partially de-smeared the image caused by the use of wide-slit collimators. An increase in resolution of about two-to-one was realized before other system limitations came into play. (In the article cited above, this type of processing had been prematurely judged to be of questionable value because of overly pessimistic estimates of the accuracy to which the detectors could be aligned. Subsequent improvements in the detector system's alignment methods, however, made the application of the deconvolution algorithm worthwhile. Rocca and his associates are now writing a paper describing their new work in this area.)

A second activity in the Communications Group is related to television signal processing. In particular, the group is continuing to study modifications to a subsystem which it designed and built to detect the motion of images within television signals. The primary system, which incorporates this subsystem, partitions each scan line within the overall picture into its variable (moving) segments and its stationary segments. The redundant data that is associated with the stationary part of the image are not transmitted. At the receiver, a stored version of the previous frame can be combined with the received transmission of *only* the moving segments (and some control data) to produce the new frame. This process reduces the required average transmitted data rate and, thereby, the bandwidth for the digital television signals of interest. The signals associated with only the moving segments are differentially encoded to enable a further reduction in the required bandwidth. The saving in transmission data rate is approximately one order of magnitude, from approximately 8 bits to about 1 bit per picture element. In general, the quality of the reproduction achieved by such a system is limited by the complexity of algorithms that are economically allowable, and this, in turn, is limited by the costs for high-speed memory capacity and arithmetic units.

Memory limitation in the IE&E's system manifests itself in a particularly disturbing way: when a significant portion of a sequence of frames includes moving segments, the buffer memories in the system become overloaded. (The "buffers" are needed to convert a nonuniform, "bursty" data sequence which emerges from the motion detector into a desirable uniform data rate for subsequent transmission.) To cope with the nearly full buffer situation, a modification is made to the input processing procedure, but because of a combination of reduced sampling rate and degraded resolution (bits) per sample, the modification causes consistently poorer quality to occur in the lower (later processed) portions of the picture. The group is studying this problem. It is also studying the effects of noise bursts on the reconstruction process and is considering the possibility of adding some error-protecting redundancy to the signal to counter that problem.

The TV signal processing project is built around a hardware-software configuration which is being modified continuously, mostly by students in IE&E's Communications Group. As part of a course entitled "Electronic Technologies," organized by Prof. Sergio Brofferio, teams comprising about four students propose modifications to the system, and then build the software and/or hardware themselves. For hardware projects, they must search for the required components, and they suffer the same frustrations in the commercial arena that practicing engineers often experience in Italy. So, quite unlike master's degree engineering graduates in the US, they come to industry prepared for the team approach to R&D activities and with the experience of having to evaluate whatever components are available and to modify system designs to accomodate component limitations.

Most of the research done within the Communications Group (even that related to ET processing) is sponsored by the Centro di Studio sulle Telecomunicazioni Spaziali (CSTS) del Consiglio Nazionale delle Ricerche (CNR), the Space Telecommunications Center of the National Research Council, Italy's counterpart to the US National Science Foundation. There is little novelty in this financial arrangement; the novelty is found in the geographical and staffing relationships that exist. As is the case for several of CNR's study centers vis-a-vis one of their sponsored groups, CSTS's offices and most of its 23-member staff are located along the same corridor in the IE&E building that houses the members of IE&E's Communications Group. The administrative and technical directors of CSTS, Prof. Francesco Carassa and Prof. Guido Tartara, respectively, and at least 10 other members of the CSTS staff are also members of IE&E's teaching and/or research staff. (Rocca, on the other hand, is not a member of the CSTS staff.) This close working relationship leaves no uncertainty as to the specification of a research program which the Communication Group of IE&E will pursue under CSTS sponsorship. The reader can therefore understand the difficulty I had in sorting out which of the CSTS-sponsored research efforts were being done "in house" at CSTS and which were being done within the IE&E's Communications Group.

I discussed CSTS's research with Tartara, who described it as a three-element program: system studies, atmospheric propagation studies, and image processing/transmission. (The latter element, of course, was the one I had just reviewed with Rocca.)

In system studies, CSTS sponsors work related to future satellite systems, signal coding and modulation techniques, multiple-access system configurations, and communication network management. Tartara commented that the CSTS staff (and CNR, in general) is currently struggling with the question of whether a new space-systems-oriented agency should be organized. In the pursuit of plans for participation in Europe's L-SAT program and for the development of Italy's own domestic communication satellites, the need seems to have arisen for control by a project management-orientated group such as NASA rather than a theoretically oriented organization like CNR. No specific schedule was indicated for reaching a decision, but the L-SAT program schedule may force one soon. A variety of government, industrial and academic organizations throughout Europe have been working with the staff of the European Space Agency (ESA) toward the development of a system definition and implementation plan for its L-SAT program. It is expected that, by the time ESA concludes its review of many suggestions and firm R&D proposals (in the late fall of this year) and publishes its recommendations, the question of how Italy will organize its internally related efforts will have to be decided.

In the area of domestic communication satellite systems, CSTS has sponsored studies which attempt to define an optimum configuration for satellite links and terrestial distribution networks. Topological (interconnection) considerations, traffic analyses and projections of future needs are being considered in conjunction with estimates of the complexity of the system switching which can logically be included within the satellite-mounted subsystem. In very general terms, Italy's specifications for the kind of services it wants from a domestic communication satellite are not much different from those of any other developed country, but Italy's particular geographical arrangement has led to the proposal of two conflicting system philosophies. One would include approximately 30 relatively small, simple, regional terrestial centers supported by a complex switching satellite system. The other would use a few complex terrestial centers supported by a relatively simple satellite relay system. The initial system-configuration decision has not been made yet; when it is made, a second basic question will remain: Is the better of the two alternates worth implementing at all, or would Italy's peculiar geography be served more cost-effectively by a completely terrestial domestic system?

Getting back to experimental activities in the satellite systems area, Tartara indicated that CSTS is continuing to conduct atmospheric propagation studies by using Italy's still-operating SIRIO experimental satellite. SIRIO was launched in August 1977 with an expected operational life of three years, but it now appears to have about one more year of orbital life remaining. For that period, two types of experimental activities have been planned: a continuation of the study of rain-induced signal attenuation and a teleconferencing experiment. The excess attenuation model which they are attempting to perfect under the guidance of Prof. Carlo Capsoni, is a nonlinear and, of course, time-varying function of the reflectivity factor along the ray path. This reflectivity factor, which is a function of the rain rate, is being measured by weather radar systems at three locations in Italy. Preliminary results of this line of

research were reported in *ALTA FREQUEZA's* July 1979 special issue which discussed the SIRIO satellite and its experimental involvement. The current work which Capsoni described is an attempt to define the resolution, in both time and distance, with which a pair of parameters in the model must be specified in order to reduce the discrepancy between the calculated values and the measured values of the excess attenuation. The purpose of this research is to help the communication satellite system designers in Italy estimate the need for space diversity in the ground terminals located within the particularly important, but exceptionally rainy region of the Po River Valley just south of the Alps. Prof. G. Drufka expressed some concern over the accuracy with which such models will be able to calculate the excess attenuation. The concern is based on two shortcomings in the process. First, he questions the accuracy with which the data from a 2-dimensional, ground-based array of rain gauges can be used to model a rainstorm in three dimensions. Secondly, he questions the accuracy of the rain gauge measurements, which are subject to distortion by prevaling surface winds. But despite that misgiving, he is analyzing an extensive set of rain-gauge data accumulated over the last ten years by the local electrical-power, water-supply, and agricultural interests in the area.

The Communications Group staff members at IE&E and their collocated alter egos at CSTS provide an educational environment for research and development which I believe is unique. The dedication of the staffs of both organizations contributes to the well-deserved reputation of the Politecnico di Milano for training future participants in another Italian Renaissance. (Philip Fire)

COMMUNICATIONS R&D AT POLITECNICO DI TORINO

The Istituto di Elettronica e Telecomunicazioni (IE&T) of the Politecnico di Torino in Turin, Italy, provides a 3-year program of study leading to the degree of Dottore-Ingenere (similar to the American MS degree *ESN* 30-7:303 [1976]). This program supplements a 2-year period of preparation in physics, chemistry, and mathematics provided by other institutes at the school. In these respects, IE&T is similar to the Istituto di Elettronica ed Elettronica (IE&E) at the Politecnico di Milano in Milan ("Communications R&D at Politecnico di Milano," *ESN* 34-9:421 [1980]).

Despite these very real similarities, however, there are substantial differences between Turin's IE&T and Milan's IE&E. In its communications-oriented research activities, IE&E at Milan specializes in baseband signal processing, TV bandwidth compression, and characterization of atmospheric attenuation at microwave frequencies, all with a strong experimental flavor. At IE&T in Turin, which has a staff of about 50 (35 professionals) and approximately 600 students, the emphasis within the communications area is on the *theoretical* characterization and simulation of nonlinear channels and the general evaluation of communication signal design, coding, and detection methods. In Milan, communications, computer science, and control theory are all included within IE&E's program, but the last two fields of study are *not* included within IE&T's program in Turin. Those topics are combined instead with other studies in another department, the Istituto di Elettrotecnica.

My host at IE&T was Prof. Sergio Benedetto. He and his colleague, Prof. Ezio Biglieri, have been studying the signaling problems caused by component nonlinearities and undesirable memory characteristics in satellite-borne communication relays.

The nonlinearities, both as simple amplitude distortions and as unwanted amplitude-to-phase modulation conversions, are induced primarily by the traveling-wave transmitting tube used in such systems. The overriding need to increase both the transmitted power level and the overall energy efficiency of the system has made it necessary to operate these tubes in their nearly saturated, and therefore significantly nonlinear regions.

The memory phenomenon considered is one which results in inter*symbol* interference (for the digital signals used). It results from the use of bandlimiting filters which are needed to prevent inter*channel* interference. Benedetto and Biglieri represent this complex channel by a Volterra-series expansion, a technique introduced by Wiener in 1942. This method generalizes, to nonlinear channels, the impulse-response method often used to analyze linear systems. The two researchers derived a bandpass form of the function which is amenable to efficient computer analysis.

The work in the above area was supported by the European Space Agency (ESA); that constitutes another difference between the "communicators" at IE&T and their counterparts at IE&E in Milan. While most of IE&E's communication work is supported by the collocated Space Telecommunications Center (CSTS) of Italy's CNR, IE&T's space communications studies are supported by such outside interests as ESA (located in the Netherlands). But to counter that "outside" support

in communications, IE&T has its own collocated CNR study center, the Centro Studi Propagazione e Antenne (CESPA).

CESPA's staff and the Electromagnetics (EM) Group within IE&T's staff are as intermingled in Turin as CSTS and IE&E are in Milan. Despite the implied restriction to radiating components in its title, CESPA also participates in and sponsors research in microwave components and, more generally, guided propagation. Assoc. Prof. Ivo Montrosset, representing Prof. Rodolfo Zich (who holds a dual appointment as head of CESPA and head of the EM Group in IE&T), described the present interests of the group. These interests include the design and analysis of dielectric waveguides, the design of antennas (ranging in size from large reflector-feed combinations used in tropospheric scattering systems to small satellite-borne units), the *start* of an activity related to optical waveguides and integrated-optics devices, and meteorological studies related to aircraft safety in the region of airports.

The last-named activity was described by F. Canavero, who is carrying on these studies under the direction of Prof. Giovanni Perona. The group has been collecting meteorological data at three locations in and near Turin. The parameter of primary interest concerns the short-term atmospheric pressure variations (over 1-minute intervals). The researchers conjecture that these variations may be used to forecast imminent wind-shear activity which could endanger a landing aircraft. The other meteorological data, taken from 15 minutes before the pressure jump to 45 minutes after, are being studied. At present, Perona and Canavero are attempting to correlate the data from the three test points (located, roughly, at the vertices of a 2-km equilateral triangle). They expect to publish the results of this work early next year.

(I subsequently discussed this subject with Mr. Michael Dutton of the British Meterological Office [Bracknell, UK]. Dutton indicated that similar wind-shear studies by A.J. Bedard of the National Oceanic and Atmospheric Administration's Wave Propagation Laboratory, performed in the vicinity of Chicago's O'Hare airport, appeared to show poorer correlation to pressure jumps than to wind vector data taken by a set of stations surrounding the airport. But, since local geographical features affect these phenomena considerably, even within the Turin study itself, previous results may not apply generally.) (Philip Fire)

ELECTRONICS

ELECTRONICS IN IRELAND—1980

Ireland has been the country of origin of a number of outstanding scientists such as Robert Boyle, George S. Stokes, John Tyndall, William R. Hamilton, and Joseph Larmor, to name only a few. While these and many others were indeed educated in Ireland, until recently most individuals trained in the sciences and engineering in Ireland accepted the inevitability after graduation of the immigrant ship which took them either to Britain or to the US. Suddenly the picture has changed—at least for those specializing in electronics. For now, not only does every such graduate have his choice of jobs in the Republic of Ireland, Ireland is actually offering significant financial inducements to qualified engineers and other specialists to encourage them to move to Ireland. This all is due to the efforts of the Irish Development Authority (IDA), which was formed a few years ago with the aim of developing the country industrially—principally by attracting electronics companies from overseas.

Foreign electronics firms have now set up 70 manufacturing facilities in Ireland, most of these within the past four years. They represent a fixed investment of about $600 million. More than 60% of these new plants are branches of American companies; other firms have come from Britain, Japan, Sweden, Denmark, Germany, and Canada. IDA has been able to bring about these developments by extremely attractive tax incentives as well as by direct investments in plants. At this time, the investment in foreign electronics plants in Ireland by the Irish government through IDA has been about $150 million.

Examples of some of the companies that have come are Mostek, which in 1984 expects to be employing 1,200 persons in a $90 million plant in Dublin; Wang Laboratories, with a $75 million facility in Limerick; Digital Equipment Corporation, employing 1,000 in Galway and presently setting up another facility in Clonmel; and Nixdorf, the German computer manufacturer, with a $10 million plant in Bray, near Dublin. While the numbers of employees involved may not seem large by American standards, for a country of only 3½ million inhabitants they are quite significant.

To bring industry into a country which does not have a large industrial base requires the solution of some special problems. For example, a major problem in attracting more industry to Ireland has been the telecommunication system. One of the individuals whom I visited on my recent trip to Ireland stated that in many cases it is easier to telephone the US from Galway (on the western coast of Ireland) than to call Dublin (on the east coast). This problem and others similar in nature are being solved by a National Board for Science and Technology. This board, whose principal mission is to produce the annual science budget for the government, is also a "think tank," with the task of removing roadblocks that stand in the way of progress in science and technology. Thanks to the recommendation of this board, the telecommunications system is now in the process of being modernized both politically and physically. Along with other actions, the Ministry of Posts and Telegraphs just recently awarded a major telecommunication contract to Telectron, a wholly-owned Irish company, to produce advanced transmission equipment and develop software for the Irish and export markets in a joint venture with Compagnie Industrielle des Telecommunications, which pioneered France's telephone industry.

It is well recognized that if Ireland is to have an electronics industry, it will need more engineers and applied scientists capable of working in the electronics field. The industrial expansion must therefore be accompanied by an expansion of graduates from higher institutions of learning. This expansion is now also in progress.

The older universities and colleges involved are the University of Dublin (Trinity College and the College of Technology) and the University Colleges of Galway, Cork, and Dublin, that are branches of the University of Ireland. Among the newer schools is the National Institute for Higher Education (NIHE) in Limerick, which was established in 1972 and has since become one of the foremost centers of activity in electronic engineering. A similar institution, NIHE-Dublin, will open its doors in October 1980. It is said that the existence of NIHE-Limerick has had a profound positive effect on the industrialization of the midwestern region of Ireland. Indeed, according to the Irish Minister for Industry and Commerce, the proximity of NIHE in Limerick was a deciding factor for Wang Laboratories, Inc., and Varian Associates, Inc., in locating plants in Limerick, adjacent to the NIHE campus.

Programs leading to the first academic degree for qualified engineers or applied physicists in Ireland are 4 years in length. The question of relative value of the material covered in courses in electronic engineering at the universities and those at the NIHEs is one also debated among engineering educators in the US. According to a professor at one of the Irish universities, the former present a broad, fundamental program, while the NIHEs were said to specialize to a greater extent. A person completing an NIHE program might therefore be very well qualified to perform practical circuit design immediately after graduating but might lack some of the broader background to which the university graduate was exposed. NIHEs do not offer graduate degrees; universities do.

During my trip I visited University Colleges Galway, Cork, and Dublin respectively, and Trinity College of the University of Dublin. My purpose in each case was to learn about activities in electronics. The following is a report on these visits.

Galway

University College Galway of the National University of Ireland opened its doors in 1849, when it was called Queen's College at Galway. It has a long history of science. Joseph Larmor, well known for his formula on precession of electrons, was the professor of physics here from 1880 to 1885. Galway's recent response to the Irish electronic revolution was to establish a Department of Electronic Engineering and also a chair of applied physics/electronics in the Physics Department. Although 20 students have enrolled in the electronic engineering program and have been in attendance and taking basic courses since October 1979, no professor or lecturers have, as yet, been appointed to the department. The chair in applied physics/electronics, however, has been filled by Prof. P.W. Walton, who returned to Ireland after about 10 years at the Medical College of Virginia (Richmond, VA).

In addition to setting up courses in his area of interest, Walton is continuing work in fluoroscopic ionography, a research topic in which he was engaged in the US. Ionography is an x-ray image-recording technique in which the detector is a thin ionization chamber that contains a heavy gas under pressure. Ions formed by x-rays in the gas are swept across the chamber by an electric field, to deposit on a thin insulating film and form a charge pattern. After some time, the chamber is depressurized, the film is

removed, and the charge pattern is made visible by a powder or liquid toner. In Walton's fluoroscopic ionography the charges are collected onto a thin, clear, deformable layer of oil or soft elastomer that coats a front-surface mirror in the chamber. Electrostatic forces between the surface charges and the conducting mirror cause deformations, which are made visible by an external Schlieren optical-projection system with light which enters and leaves the chamber through a glass window, so that there is no need to remove the film. Walton has obtained images with resolution better than and sensitivity close to those obtained with film/screen methods. The initial support for this work was from the National Institute of Health (US). Walton is now trying to obtain funds for work to minimize aberrations in the system and to bring the technique to technical fruition.

Other work in the department deals with incorporating microprocessors into student laboratories and also into experimental research work. The department has advertised for two additional lecturers in applied physics/electronics but has found them difficult to obtain. One possible reason may be that, according to university policy, lecturers should be able to teach in Irish (Gaelic) as well as in English, since Galway was designated some years ago as the College of the National University of Ireland in which instruction could be taken in English or Irish. While such an announcement may discourage a number of applicants initially, this policy cannot actually be strictly adhered to, because the requisite staff fluent in both languages cannot be found. As a result, many positions are filled with persons who are not fluent in Irish.

Cork

Not a child of the late 70s but reasonably well established is the Department of Electrical Engineering at University College Cork, of which Prof. M.P. Sexton is chairman. The department has a 4-year undergraduate program, with about 45 first-year students admitted each year. Sexton told me that since the students are carefully selected before admission, there are virtually no dropouts. In addition to course work, there is a strong emphasis in the undergraduate program on laboratory performance, culminating in a final-year project that is virtually a full-time endeavor during the last two quarters. An MSc program of 1½ years duration and based on research alone is also in existence, with current projects in lasers, telecommunications, solid-state electronics and electrical machines. There are also several PhD students.

Among the research projects being carried out under the direction of Sexton are work in far-infrared gas laser technology; design, construction and operation of a 12 GHz earth station for communication satellites; microprocessor control of industrial processes; and a rather unusual project based on the measurement of the dielectric properties of Irish butter and the use of these properties for moisture control in continuous butter makers. The laser work, which is sponsored by several organizations (including the EEC), involves power and gain measurements on a pulsed heavy-water gas laser, frequency modulation of a CO_2 laser with cadmium telluride crystals, and optical pumping of heavy-water vapor by a CO_2 laser. The work dealing with communication to satellites, which is funded by the European Space Agency, consists of a study of the down-link propagation characteristics, with particular attention to the effects of meteorological conditions, and direct satellite reception of experimental color TV transmissions relayed from Italy and the UK via a geostationary satellite. This work is being carried out in collaboration with University College Dublin and others.

While these are interesting projects, more immediately in line with Ireland's progress in establishing solid-state electronics is that University College Cork has recently been commissioned to establish a microelectronics research center, at an initial cost of approximately $2,000,000. Assoc. Prof. G.T. Wrixon has been appointed director for an initial period of 3 years; Dr. Liam M. Kelly will be a senior staff member. The center is to educate engineers for work in the microelectronics industry and to serve as a centralized R&D laboratory in which cooperative university/industry research projects involving new processes and development in microelectronics can be carried out. Wrixon (MS, Cal Tech; PhD, U. of Cal, Berkeley) worked at Bell Laboratories for several years prior to returning to Ireland. Kelly performed his graduate work at the University of California, Santa Cruz.

The establishment of the center actually is a natural extension of the activity in electrical engineering at Cork that Wrixon has carried on since 1974. Based on his experience at Bell Laboratories, Wrixon established a facility for fabricating millimeter and submillimeter wave Schottky-barrier diodes under grants and contracts with laboratories engaged in radio astronomy and other millimeter wave endeavors in various countries in Europe. Wrixon and Kelly

are experts in the fabrication and testing of these gallium arsenide (GaAs) diodes; a recent example of their work shows diodes with an epitaxial layer thickness of less than 1000 Å and doping level of 2.5×10^{16} cm^{-3} yielding a mixer noise temperature of 98 K at 115 GHz. These diodes have a diameter of 1.8 μm and show repeatable performance.

Work contemplated for the new microelectronics center involves creation of a silicon CMOS line, thick film/hybrid circuits, continued Schottky-barrier diode fabrication and testing, GaAs MOS solar cells, microprocessor development, and the fabrication of GaAs FETs and GaAs integrated circuits. Wrixon and Kelly have already started on work related to integrated circuits in that they have developed a system of using the university's JEOL scanning electron microscope for electron-beam lithography, with a resolution of ¼ μm. They are presently fabricating cross-shaped Schottky-barrier diodes of the same vertical structure as their circular diodes but of lower series resistance. In solar-cell work they have obtained 18% efficiency with single crystal MOS GaAs solar cells in which the oxide layer was 70 Å thick and plasma grown. With another type of MOS solar cell, using gallium sputtered on tungsten in an arsine environment, the efficiency was 10%.

Dublin

University College Dublin (UCD) has about 10,000 students. This university used to be entirely in the city of Dublin, but the major portion of it has now moved to a new campus outside the city. Engineering, however, has not yet moved but remains ensconced in a very imposing structure located within the complex of government buildings in Dublin, adjacent to the building that houses the office of the Taoiseach (the Prime Minister of the Republic of Ireland). UCD graduates around 50 students per year in electrical and electronic engineering (EEE), a number presently limited by the size of the physical plant. (The building was designed for 200 students; 800 are currently using it.) There are presently 12 graduate students in EEE; some of these are MSc students, others are working on a PhD. The academic staff in EEE comprises 16 staff members.

I talked for some time with Dr. J.O. Scanlan, professor of electronic engineering who, among other distinctions, is a Fellow of IEEE. Scanlan's expertise is in the broad area of electrical filters and systems. His earlier work dealt with microwave filters which, he stated, are basically composed of time delays and elements that perform arithmetic on the signal—ideas that also prevail in his more recent efforts in sampled data filters. These efforts were initially aimed at investigating methods of improving the performance of charge-coupled device (CCD) filters. Experimental and theoretical studies of the sensitivity of tapped CCD delay line filters confirmed, however, that with this type of structure there are serious limitations in attempting to achieve severe filtering requirements. Scanlan has therefore extended his work to encompass the study of alternative means of filter realization suitable for implementation in single-chip form. This is a cooperative project between UCD and the University of Edinburgh (where an integrated circuits laboratory exists) and is supported by the National Board for Science and Technology in Ireland and in Edinburgh by the UK Science Research Council. Scanlan's alternative structures are based on adapting ideas used in digital filters technology, to produce sampled data filters with similar optimum sensitivity properties. A number of breadboard models have been constructed and have shown very attractive performance features, such as the fact that the frequency to which these filters will work is ½ the clock rate—a much higher frequency than obtained by others.

Another of Scanlan's filter projects has evolved into a new synthesis technique for the design of switched-capacitor state variable filters with unrestricted sampling rate. This appears to offer considerable advantages in terms of the required capacitor size ratios. Present work is aimed at exploring the resulting design trade-offs and at producing optimum filters in breadboard form.

Scanlan's third major project has dealt with system simulation. Broadly, the objective is to design the cheapest earth station that gives desired results for satellite communication. UCD is about to receive a transmit/receive station designed at UCD and built by Ericcson (Sweden). One of the objectives of this station is participation in the so-called STELLA high-speed data transmission experiments. This will involve the reception of computer data at the Dublin earth station from CERN (Geneva) and other laboratories and should allow virtually interactive systems for physics experiments being performed at CERN and other laboratories all over Europe. Funding is in part by the EEC.

Other research projects in the department include variable-speed drive systems for high-power stepper motors; dynamics of inherently unbalanced induc-

tion motors; system identification applied to optical processors (in conjunction with the Eye and Ear Hospital); microcomputer control of greenhouse environment; measurement and control in milking parlors; anti-skid breaking systems for cars; high-voltage phenomena in low-temperature liquids; various electronic techniques for waveform generation; data transmission; distributed telemetry; circuit theory; and aerodynamic theory and control of windmills. This windmill project is the work of Prof. H.M. Power (an appropriate name!) who believes that windpower is one of Ireland's greatest natural resources.

Trinity

My final visit was to the Engineering School of Trinity College of the University of Dublin. While Trinity College has a beautiful campus in downtown Dublin, electrical engineering has not had the benefit of this beauty. For although the department is located in the immediate vicinity of the campus, it is in a building that appears to be either an old office building or a former private residence. Because of the rapid increase in student enrollment, however, the department will soon move onto the campus. The chairman, Prof. Brendon Scaife, told me that 3 years ago there were only 14 academic staff members in all the engineering departments at Trinity; only 4 of these were in electrical engineering. Now there are 9 staff members in electrical engineering, with 3 more to be appointed. Whereas the graduating class of the department this year has only 12 students, it is expected that the new class will number about 50. To keep up with this increase in both student and faculty populations, Trinity College is now remodeling one of the buildings on its campus specifically for electrical engineering.

Although, with such a small staff, research has had to be at a minimum, Scaife himself has been performing theoretical research on dielectrics, noise, and irreversibility and, together with a brother, Prof. W.G.S. Scaife, has studied pressure dependence of complex dielectric constants of liquids and gases at pressures up to 3000 bars.

An interesting venture within the past decade or so at Trinity College has been a "modular course for the degree MAI (Master in Arte Ingenieria). A modular course is one in which a student spends part of his time in industry and part at the university. In the MAI course, candidates are obliged to complete, among other subjects, an industrial project in design, construction, development, or production. The work is supervised jointly by a member of the staff of the Engineering School and by the engineer in the industry in question.

Before leaving Electronics at Irish universities, a note about support of students is in order. Although Irish universities operate very much on the British model, where instruction for British subjects is free, in Ireland only 15 to 20% of the students have scholarships; the others need to pay £400 per year. Postgraduate students receive on the order of £1,300 per year to perform research which leads toward a thesis. As is well known to graduate students in many universities in the US, it is possible to exist with this kind of support, but one certainly does not become obese from overeating.

In conclusion, it is fair to summarize electronics in Ireland by noting that the electronic revolution has indeed reached Ireland, Perhaps it may be a bit of an overstatement of the IDA to say that Ireland is fast becoming the Silicon Valley of Europe, but there is no question that Ireland is trying hard to be successful both in industry and in electrical and electronic engineering education.
(Irving Kaufman)

SEMICONDUCTORS IN ESPOO, SUOMI

At present there is no integrated circuits (IC) laboratory in Finland, but Prof. T. Stubb may soon be starting one. Stubb is a professor in the Electrical Engineering Department (EE) of the Technical University of Helsinki (TUH) and also the director of the Semiconductor Laboratory (SL) of the Technical Research Centre of Finland (TRCF). (The Finnish name for Finland is Suomi, that for TUH is Helsingin Teknillinen Korkeakoulu, and TRCF, in Finnish, is Valtion Teknillinen Tutkimuskeskus.)

TUH was established about 100 years ago, but does not show its age because it is situated on a brand-new campus in Espoo, a short distance from Helsinki. There are about 6,000 students in attendance, of whom approximately 500 to 600 are in EE.

The undergraduate program in EE at TUH covers 4 years, but the average student requires 5 to 6 years to obtain the diploma, i.e., to graduate. By the time he or she has finished, the student has spent at least half a year on a thesis. A person electing to continue studies at TUH can qualify for a second degree, the Lisensiaattityö (Licentiate), after two more years of effort. The final degree is the doctorate, which may be obtained after completion of a more extensive thesis.

TUH carries out both teaching and research, while TRCF is strictly a research organization. It appears that the Finnish government realized however, that semiconductor research requires equipment so expensive that it would make good sense to have only one such facility. SL is that facility, and it is located within TUH.

Stubb, my genial host, mentioned that he had been a visiting professor in Florida and might be interested in spending some additional time in the US after his retirement two years hence. He thought also that at that time SL would probably split into two separate laboratories.

The 43 individuals in SL are engaged in work with thin-film sensors, magnetic semiconductors, MOS and planar technology, and integrated optics. Some of those activities are being carried on in conjunction with other laboratories.

The person responsible for thin-film activity is Dr. T. Wiik, who briefly described his work: fabricating and testing Josephson junctions, humidity sensors, and sensors using surface acoustic waves (SAW).

The Josephson junctions Wiik prepares have an oxided niobium film on Corning glass in contact with a lead film. (The oxide layer, around 20 Å thick, is deposited on the niobium by a glow discharge.) The junctions, which are used in SQUIDS (Superconducting Quantum Interference Devices) for measuring magnetic fields (and currents) and for microwave generator/detector applications, are being supplied to other laboratories in Finland.

Wiik told me that his group had developed a simple humidity sensor that is now being marketed world-wide for radiosondes by the Finnish firm Vaisala. The sensor consists of two metal film stripes on glass that are covered by an organic material (proprietary). The humidity is found by a measurement of the film-to-film resistance; response time is 1 second.

In discussing his SAW sensors, Wiik said only that such devices would measure physical quantitites and operate at several hundred MHz; he made it clear that all other information about them was proprietary.

In contrast to the applied work of Wiik are the more basic studies of the group led by Dr. J. Heleskivi which has been investigating magnetic semiconductors, specifically europium chalcogenides and $Cd_xMn_{1-x}Te$. The europium compounds (EuO and EuSe) are grown in-house by H. Stubb, son of the director; the specimens of $Cd_xMn_{1-x}Te$ were recently obtained from Prof. R.R. Galazka (Univ. of Warsaw, Warsaw, Poland). These compounds can exhibit interaction between electrical and magnetic properties. For example, the electrical conductivity of the europium compounds can change by orders of magnitude when the magnetic field in which they are immersed is changed from 0 up to 10 tesla. This requires cooling to low temperatures—for EuO, 69 K; for EuSe, below 4.6 K. French investigators, working with Galazka's materials, have found electric/magnetic interactions at temperatures up to 100 K.

Heleskivi explained that these materials have donor levels that are magnetic field dependent. In addition, the bandgap E_g can be changed by strong magnetic fields. For example, EuSe with room temperature E_g of 1.85eV, will undergo a change in E_g of 0.2 eV when placed in a 1 tesla field. Both effects will result in large changes in carrier concentration and therefore in conductivity.

In addition to the recent measurements it made of relaxation times of photoexcited carriers and of photosensitivity of EuSe, Heleskivi's group has also measured the dependence of ferromagnetic resonance line width on microwave conductivity in EuSe at liquid helium temperatures and has determined that the principal contribution to line width is the relaxation of magnons due to charge carriers.

In response to my engineering-oriented questions about possible applications, Heleskivi suggested that if materials could be found that exhibited some of the characteristics mentioned at room temperature, they could be used to detect very small magnetic bubbles, and could also be utilized in sensors.

Dr. M. Leppihalme and his group have tackled various aspects of optoelectronics, including the fabrication of optical fibers and solar cells. They have measured barrier heights of Schottky barrier structures on n and p-type silicon and germanium; they have looked at phonon energies in these materials; they have made semiconductor optical detectors as well as single-crystal zinc sulfide Schottky barrier diodes for ultraviolet light detection; they have measured mode spectra of lasers; and they have fabricated integrated-optics components with zinc sulfide films. In their present work, on MIS (metal-insulator semiconductor) solar cells of polycrystalline silicon, their initial attempts to reduce the surface state density by the introduction of fluorine into the insulating oxide layer have had encouraging results, as evidenced by the I-V characteristics these cells exhibit.

In work aimed at the fabrication of microwave devices, Dr. P. Krusius and a student have been examining the high frequency behavior of MIS structures on a theoretical basis. The general procedure

is to investigate the tunnelling and other current components and their dependence on voltage, temperature and frequency.

At the beginning of this article I mentioned the possibility that Finland might soon have its first IC laboratory This would require a considerable capital investment. For, while SL has had diffusion furnaces in operation for several years and is able to fabricate MOS devices, masks are still being prepared by the rubylith method. This is not meant to imply that SL has not been able to fabricate interesting devices (such as a zinc oxide silicon pressure transducer), but rather that the emphasis has been on device research, not IC fabrication. It will be interesting to see whether the pressure to establish IC work in Finland will change this emphasis. (Irving Kaufman)

ENERGY

SOLAR ENERGY RESEARCH AT THE UNIVERSITY OF GRANADA

Spain is one of those countries blessed with a sufficiently low latitude and generally cloudless skies as to find solar energy comparatively promising. In fact, the southern coast of Spain, eastward from Gibraltar, has long been known as the "Costa del Sol." It is there that solar energy research is concentrated, particularly in Almeria and in the nearby city of Granada. I was unable to visit Almeria where the experimental work goes on, but I did visit Antonio Echarri, professor of physics at the University of Granada, who is doing interesting theoretical studies of solar energy. He has a master's degree in mathematics, and 2 doctorates in physics, one from Grenoble University in France and one from Zaragoza University in Spain. (He also speaks excellent English, a comparative rarity among Spaniards.) Echarri's research was originally in low-temperature metallurgy, especially superconductivity, but he was unable to obtain liquid helium at Granada to continue this research, and so turned to solar-energy work.

Figure 1 shows a Harwell-Stirling gaseous-piston pump. The water in the right-hand branch is cold and, as indicated, the water in the central branch is hot. Heat is applied to the vapor space between them and oscillations are set up. These oscillations are transmitted to the left-hand branch where the water eventually rises to a considerable height and spills over, thus constituting pumping action. Thermodynamically, the situation is related to that of the Stirling-cycle engine, hence the name. By varying the geometry of the device, that is, the diameters and lengths of each of the various sections, together with the pressures and temperatures, one can affect the stability (in this unusual case, one is actually seeking instability). The stability conditions are investigated by the method of Liapunov, leading to a partial differential equation (LaGrangian equation); Echarri is busy obtaining numerical solutions to this equation on a Univac digital computer located in Madrid. He and his group are also building a model of the device to check their theoretical results. They are hoping to develop this device as a pump for rural use, to be powered exclusively by solar energy. Pumping is of course an excellent use of solar energy, since water can be pumped up and stored when the sun is present, and then the water drawn down during cloudy periods or at night. In other words, pumping (unlike some other uses) does not require continuous insolation.

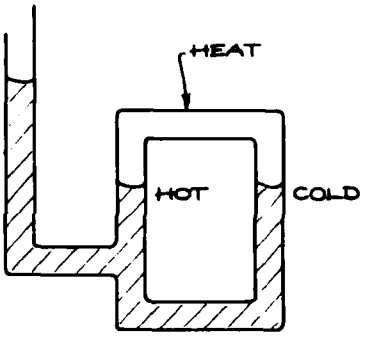
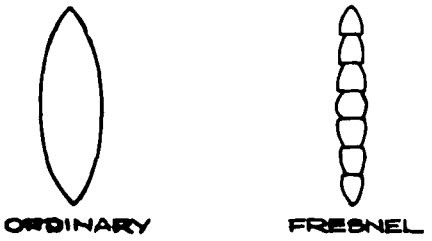


Figure 1

Another pumping device being investigated by Echarri's group is a modification of the Savery pump, which was used more than 200 years ago (in James Watt's time) for pumping water out of mines. It uses heat to create plugs of water separated by water vapor which can be drawn up a pipe by suction-like forces to a maximum height of about 10 meters. It seems that a modification of this device powered by solar energy may be of use once again in primitive countries. Again, Echarri's group is doing a theoretical analysis, and has built a model; the model is heated with an alcohol burner, and has thus far been able to raise water to a height of 1 meter.

Finally, the group is working on Fresnel lenses to concentrate sunlight on photovoltaic silicon cells. A Fresnel lens is one in which an ordinary lens, as in figure 2a, is collapsed to make a very thin lens having the same effect,

as in Figure 2b.



a. b.

Figure 2

Since such lenses are cheaper than silicon cells, it is better to use a large lens and concentrate the sunlight on a small cell than to use a large area of cells. However, such lenses tend to be too good, concentrating the sunlight on one part of the cell (which becomes overheated) while other parts are inadequately illuminated. What is needed is a little more spherical aberration to blur out the focus. Furthermore, the Fresnel lens tends to be round while the cell tends to be square. Echarri's clever development involves a cylindrical Fresnel lens (which focuses the light to a line instead of a point) modified to create sufficient aberration to spread the line uniformly into a strip one-half inch to one inch wide; and this is matched to a strip of silicon cells of exactly that width. They are using digital computers to solve the equations for the optics for various designs for this apparatus, and are beginning to construct the appropriate lenses out of methyl methacrylate plastics. Finally, they are using water to cool the silicon cells (they become inefficient if allowed to rise in temperature), and this heated water can be used for domestic hot water. It is also necessary to keep the whole lens-cell complex pointed directly at the sun, and they have created an elevation-azimuth mount on rails with an automatic control system which hunts in such a way that the system is continuously pointed correctly.

It is of interest to note that there is considerable geothermal activity in Spain, and there is some rather fundamental research in the Physics Department at Granada aimed at developing an understanding of the geothermal processes. In some cases the heat arises from tectonic activity, in others from submerged radioactivity, and both of these sources are observed in Spain. When the geology is sufficiently well understood, it will be possible to determine where it is profitable to drill more deeply in order to exploit these geothermal energy sources. (Robert E. Machol)

ENGINEERING

THE MICROWAVE LABORATORY OF DELFT

The Microwave Laboratory of the Electrical Engineering (EE) Department of the Technical University of Delft is a substantially *autonomous* institute, headed by Prof. ir. L. Krul, who was my host during a recent visit there. The EE Department moved to its present modern building on a new campus in 1969. It is a 23-story building providing 20,000 m^2 of floor space—and a beautiful view from Krul's office. The Technical University itself dates from 1842 and the Engineering Department from 1905. There are about 1,500 EE students studying for a diploma in engineering, roughly equivalent to a master's degree, and there is a staff of about 400. As noted previously (*ESN* 34-5:226), Dutch students easily obtain financial aid and are under no pressure to complete their studies in a given time. The average time taken is 6 to 7 years. This and attrition account for the fact that only about 120 students graduate each year. This is about 40% of the yearly requirement for new EEs in the Netherlands.

The Microwave Laboratory has a staff of 13, and has 5 postgraduate students. Research support funds come mainly from the university, but also from the government or its institutes, such as the Netherlands Organization for Applied Scientific Research (TNO) or the National Aerospace Laboratory (NLR). The Microwave Laboratory has four major projects, described below.

The remote-sensing project is government supported. In this project the nature of airborne radar ground returns are studied. In one application, radar echoes from the North Sea are analyzed in an attempt to measure wave heights which may then be correlated with wind velocity. The main investigation concerns echo characteristics from vegetation. Here the aim is to be able to recognize and map the different crops, predict yields, recognize changes in the environment, detect diseases of crops or forests, and determine soil conditions such as lack of moisture. Ir. E.P.W. Attema showed a real-aperture side-looking radar that is being prepared for the work. It was a modified X-Band Decca radar in which all modifications had been carried out by the laboratory. First results were obtained by measurement from a tower. An 8 mm FM-CW (frequency modulated continuous wave) radar is scheduled to be ready later this year. It will include an antenna with low side lobes and a polarization diversity transmit-receive system. A second group is trying to model ground returns and describe the reflection coefficients theoretically.

A further project under Krul is tasked to look at the applications of microwaves for industrial, scientific, and medical purposes. Dielectric-constant and loss-tangent measurements are performed on both solids and liquids using a cavity method (samples are introduced into the cavity and the changes in its resonance response are observed.) A theory has been developed to correct for the effects of the container in the case of liquids. The samples may be heated so that the parameters can be measured as a function of temperature. Microwave heating processes are dependent on these properties and are of interest not only for industrial purposes such as drying of timber and the extraction of aromatic substances, but also in medicine. Unfocused irradiation of the throat is being investigated as a cancer treatment in a cooperative program with the medical school of the Erasmus University of Rotterdam. Again, the work includes modeling.

In a microwave-components project Mr. J.L. Tauritz (who is from the US) showed his network analyzer which he claimed was an improvement over commercially available versions. It uses its own microprocessor and a Hewlett-Packard synthesizer. The short term stability was claimed as .01 dB; The system is now operational and is used for automated measurements of, for example, transistors, YIGs, and microstrip circuits. Ir. M.K. Smit has investigated the accuracy of the measured data and is about to publish a paper on the subject.

Last, but certainly not least, was the antennas and propagation project. Ir. L.P. Ligthart described his university-supported tropospheric investigation with an extremely sensitive radar. His laboratory with the radar is on the top floor of the 23-story EE building. The radar operates at 3.3 GHz using an FM-CW system with chirp (linear frequency modulation). The transmitter power is 150 W maximum, which is a large amount of power for continuous operation and most of the experiments are carried out with much lower levels. Separate transmitting and receiving antennas are on the roof with diameters of 4 and 2 m respectively. The minimum range possible with the system is 60 m. It was claimed that with full power the system could detect a target as small as 7 × 7 μm at a range of 1 km. A waterfall type of display was used showing time vs range with the signal level modulating the brightness. The band-width is variable from 1-50 MHz giving a range

resolution of 150-3 m. Usually the antennas look straight up, but they can be tilted, and Ligthart plans to use scanning in future systems. The maximum range at which meteorological fronts can be detected is 75 km. Clear air turbulences can be seen at times and are studied. The system has been in operation since summer 1979. I saw a demonstration and observed some disturbances, a few hundred meters in altitude, slowly drifting through the time/range display. The radar can certainly detect dust which has been noted to collect below inversion layers. Meteorological data is obtained from a nearby airport and is correlated. During weekends the equipment is left running and the observations are recorded for later "quick look" examinations.

An antenna range was available from the roof of the EE building to the roof of a nearby high-rise apartment building. Indoor antenna measurements with small antennas could be taken in a completely shielded anechoic chamber said to give at least 70 dB attenuation to multipaths. The absorbing material was made by the Plessey Company in England.

Krul's microwave laboratory occupies a unique position in Holland where it is without competition in its special endeavors to cater for both scientific studies and industrial needs. (Theodore C. Cheston)

ENVIRONMENTAL SCIENCE

THE EUTROPHICATION OF LAKE BALATON

Lake Balaton is the largest lake in Central Europe with a total area of 600 square kilometers. At its nearest point to Budapest, it is 100 km southwest of that city, and it stretches another 70 km farther away. It is fed principally by a tiny river at its western end, and drains some 6000 km^2 of Central Hungary. Near the eastern end is a small outflow running into the Danube. The lake is unusually shallow, with an average depth of only 3.1 m. It has an uncharacteristically greenish color due to some carbonate minerals which are suspended in it in finely divided form.

The despoliation of our air and water resources is now a universal and global problem (*ESN* 34-2:62), and Lake Balaton is no exception. In this case, however, pollution in the ordinary sense is not a problem: there is very little industry in the lake's watershed, and the effluent from such industry as exists is well controlled. The problem is in some sense just the opposite of pollution; namely, enrichment of the lake, a phenomenon known to environmentalists as eutrophication. The word "pollution" generally makes one think of germs and of toxic or hazardous chemicals. In this case the lake is being spoiled by excessive amounts of the basic foodstuffs of plant and animal life; specifically, phosphorus and nitrogen, which are 2 of the 3 basic elements of fertilizers (the third is potassium, which is not involved in this process). Phosphate seems to be the chief culprit. The lifetime of a phosphate molecule in Lake Balaton is in the neighborhood of 10 minutes, after which it is incorporated into the algae and other microscopic plantlife in the lake.

If this process continues too long two unfortunate things happen: first, the lake begins to turn a dark, opaque green like a pool of stagnant water. This is aesthetically undesirable and may have a bad odor associated with it. When the level of chlorophyll (the green coloring matter of plants) exceeds 200 milligrams per cubic meter, people in general will not swim in the water. At the western end of Lake Balaton, which is the most highly eutrophied portion and also the most heavily populated and the chief resort area, the level is already up to 100 mg/m^3. Secondly, there are occasional sudden and drastic changes in the eutrophied lake which result in so-called "fish kills," which appear to be due to the following mechanism: The upper layers of the water become so opaque that sunlight cannot filter down to the deeper water. The algae in this deeper water therefore die, so the oxygen production normally arising from the algae ceases and the water begins to become deoxygenated. At the same time, the dead algae begin to decompose, consuming what oxygen remains so that the water becomes completely deoxygenated. The situation is further aggravated by release of phosphate from the mud in the bottom of the lake when it becomes anaerobic. At this point, virtually all of the fish in the lake die more or less simultaneously and float to the surface, whence many are washed onto the shore where they create a horrible smell. Catastrophic fish kills, probably due to the above mechanism, occurred in 1965 and again in 1975, and were largely responsible for the present major interest in stopping and eventually reversing the eutrophication of Lake Balaton.

At the Biological Institute of the Hungarian Academy of Sciences at Tihany, on a peninsula near the middle of the north side of Lake Balaton, there is a significant research project centered around this problem. This institute was

founded in 1927 and retains the original name, although in fact there is now a larger biological research institute in Szeged. The director of the Institute is Janos Salanki, a distinguished scientist and a member of the Hungarian Academy of Sciences. The Institute has about 22 professional scientists and, because of its isolation, an unusually large support staff, including gardeners, drivers, cooks, and the like, bringing the total staff to 70. It is extraordinarily well equipped, having its own small research ship, a Tesla (Czech) electron microscope, a liquid scintillation counter, together with numerous microscopes and much sophisticated electronic equipment. While it has only a tiny Hungarian-built computer, it does have access to other computers, especially those at SzTAKI, the Hungarian Computer and Automation Institute (to be described in *ESN* next month). More than half of the staff are concerned with the eutrophication problem.

I talked with Ferenc Mate, the deputy director of the Institute, and Sandor Herodek, a senior member. Mate, originally an agricultural chemist, is now concerned largely with administration, as deputy director, and as secretary of the coordinating committee for the Lake Balaton Project, a major endeavor involving numerous institutes and universities throughout Hungary. Herodek, originally a biochemist who did his doctoral research on lipids, is now exclusively concerned with limnology, the science of lakes, and in particular with the eutrophication of Lake Balaton.

There are two basic sources of the enrichment which creates the eutrophication: sewage and agriculture. Lake Balaton is a principal resort area for all of Hungary and for some of the surrounding countries. Every summer 2 million tourists spend an average of 7 1/2 days each on the lake. (As an interesting though perhaps irrelevent sidelight, these tourists consume some 360 tons of suntan oil each year, much of which finds its way into the lake). Each of these people inserts about 3 grams of phosphorus per day into the sewage which eventually finds its way into the lake. Half of the 3 grams of phosphorus is in the form of physiological waste; the other half comes from detergents. The sewage is thoroughly purified, which means that all the organic material in it is destroyed and it is in no way polluting. But the phosphorus is *not* removed by primary or secondary sewage treatment; removing the phosphorus requires special and expensive tertiary treatment. Many American cities have forbidden the use of phosphate-containing detergents for just this reason. In Hungary, however, such prohibition seems to be infeasible, since phosphate-containing detergents are apparently more effective than non-phosphate substitutes, and the great bulk of the detergents used in Hungary drain elsewhere than into Lake Balaton. Whether phosphate-containing detergents are really more effective is subject to some controversy, but as long as people believe they are, they will continue to use them. It is noteworthy that Swiss tourists in Hungary apparently buy large quantities of phosphate-containing detergents to take back to Switzerland where they cannot be purchased.

The other source of phosphates is fertilizing material. Fertilizers are being used in increasing quantities in Hungary for agriculture and are of paramount importance in making that agriculture efficient. The amount of phosphorus, nitrogen, and potassium in the fertilizers used in the agricultural land around Lake Balaton now averages 400 kg per hectare, which is 7 times as high as 20 years ago. Much of the phosphorus in this fertilizer eventually finds its way into the lake.

There are a number of possible ways to fight the eutrophication, and undoubtedly some combination of them will eventually be employed. One might forbid the sale of phosphate-containing detergents throughout Hungary—which would entail severe political problems—or forbid such sale just in the more densely populated areas around the western end of the lake—in which case the tourists would probably buy their detergents in Budapest and bring them to the lake. One could build tertiary treatment plants to precipitate the phosphates. One could build a pipeline around the entire circumference of the lake, to receive all of the treated sewage and dump it into the outflow which eventually leads to the Danube River. This would not transfer as much of a problem to the Danube as one might expect. Eutrophication of rivers is much less important than eutrophication of lakes. The problem in the Danube is pollution, not eutrophication, and so this extra phosphate load probably would not be serious. Furthermore, pollution of the Danube is not just Hungary's problem. It is already polluted when it reaches Hungary, and beyond Lake Balaton and Budapest, it flows out of Hungary, through Yugoslavia, and on past Romania and Bulgaria into the Black Sea.

One can prevent the runoff from agriculture to a very large extent by preventing erosion; that is, if the soil stays on the land, most of the phosphate stays with it. This can be accomplished in a number of ways, such as by contour plowing, which involves the use of specialized and expensive tractors and other agricultural equipment, or by terracing. There are side benefits to any method of preventing erosion, both in conservation of topsoil and in retention of the fertili-

needed for subsequent generations of crops. Another suggestion being investigated is to build a reservoir at the inlet to Lake Balaton and to plant in this reservoir certain types of reeds which absorb phosphorus. The reeds would be cut from time to time, taken far from the lake, and burnt, leaving the phosphorus on the land away from the lake. How well this device would work is still a matter of some controversy.

Another ingenious suggestion made was to introduce into the lake phytophagous (plant-eating) fish. At the present time the algae are eaten by small crustaceans which are eaten by larger crustaceans which are eaten by small fish which then are eaten by larger fish. Eventually, the pike perch (*Lucioperca*), a fine sport fish which tastes delicious and weighs several kilograms, is at the end of the food chain. Since each step in this food chain is only about 10% efficient, the fish do not contribute in a significant way to keeping down the population of the algae. Fish which eat algae directly might solve the problem—but then again they might not, and introducing a new species into a complex ecological system is always very risky.

Each of these proposed methods is very expensive. For example, Lake Washington, near Seattle, had a similar problem, which was solved by building a circumferential sewage line at a cost of $85 million. The circumference of Lake Balaton is about 3 times as great as that of Lake Washington, and since conditions in the two lakes are comparable, it is estimated that the total cost of such a solution would be about 1/4 billion dollars.

Part of the Lake Balaton project is concerned with collecting relevant data and developing better methods for collecting such data. For example, the photosynthetic activity is measured by filling bottles with a dilute solution of sodium carbonate containing radioactive carbon and exposing the bottles at various depths for 4 hours. The contents are then filtered to remove the algae and the radioactivity in the algae is measured. From this, and the concentration of carbon dioxide in the water, one can calculate the photosynthetic rate, which is a measure of the concentration of the phytoplankton, which in turn is a measure of the eutrophication. Recent data show that the degree of eutrophication is 8 times higher in the southwestern part of the lake than it is at Tihany, whereas 15 years ago it was uniform throughout the lake. Furthermore, even at Tihany it is much more advanced than it used to be.

One of the objectives of the project obviously is to determine the best mixture of methods for solving the eutrophication problem. Another is to determine how long the necessary financial investment may be safely delayed, which involves the question of the reversibility of eutrophication after it has developed. In the case of Lake Washington it required 4 or 5 years for the water in the lake to be replaced by water not containing phosphorus. Because Balaton is so shallow it takes only 2.2 years to replace all the water. However, in shallow lakes most of the phosphorus is stored in the mud on the bottom. If that mud becomes saturated with phosphates, it may take 20 or more years to reverse the process.

The project is concerned with construction of models of three types: (1) ecological models, to establish how the lake reacts to nutrients; (2) nutrient models, to determine where the nutrients come from and how they are distributed; and (3) management models, to aid in the decisions indicated above. SzTAKI (See next month) and IIASA (*ESN* 34-6:303) are cooperating in the construction of these models and in supplying computers to operate them. There are still many open questions: How does the lake react to nutrient loads (nitrogen and phosphorus)? Is the nitrogen also an important nutrient, or is phosphorus the only thing that matters? How does the eutrophication react to temperature? To solar radiation? To windspeed? How do the different species of algae influence these reactions? There are actually 1,000 species of algae in the lake, but the models at present includes only 3 groups of species, namely, the green, the blue-green, and the diatoms.

The IIASA models are written in Fortran and the SzTAKI models are written in Simula. The life and death of the algae are modeled, as is the dead organic material and the sediment. The model is a very elementary one at the present time, working for only a single homogenous basin of the lake (so that it must be rerun for different parts of the lake). It is simulated on a day-to-day basis, and a 1-year simulation takes about 15 minutes on SzTAKI's CDC-3300 (a rather small computer). At the present time the model is not good enough to justify confidence that it will respond to the management questions, but it seems to be an extremely useful tool for coordinating research efforts.

It seems clear at this time that at the very least, a small pipeline will be built to conduct treated sewage away from the lake and directly into the Danube. Among the outcomes of the present project will surely be recommendations concerning the optimal mix of expenditures and the optimal scheduling of such expenditures. The entire project now involves about

140 man years of effort each year, including questions of hygiene, legislation, analytical chemistry, and a wide variety of other subjects. What have been discussed here are only the limnological and modeling aspects of the effort. Nonetheless, reassured by the knowledge that there are bodies of water such as Lake Washington in which the process of eutrophication has been successfully reversed, the people on the Lake Balaton Project seem justifiably optimistic that they will find a successful solution to their own problems as well. (Robert E. Machol)

MATERIALS SCIENCE

MATERIALS SCIENCE IN EGYPT

Egypt is a country of contrasts. In the city of Cairo, for example, modern office buildings and hotels with all the amenities provide magnificent vistas of the ancient Great Pyramids of Giza. Modern automobiles share the right of way with donkeys and donkey carts and with passers-by on foot. In this commingled atmosphere of past and present, Egypt is a nation looking to the future. The peace initiative with Israel has been welcomed by almost all Egyptians at every level and has given them renewed impetus to get on with the development of their country. The same sense of purpose is attracting foreign investments, United Nations aid and international loans. In view of all this, it is not too surprising that we were able to observe some very impressive research and development efforts during a recent visit there. It would be presumptive to attempt to present an in-depth analysis of science in Egypt. Nevertheless, we hope this brief account of work in materials science offers some new insights.

The University of Alexandria Research Centre (UNARC) has been described previously (*ESN* 33-7:287). Briefly, it was started as a UNESCO/UNDP (United States Education, Science, and Cultural Organization/United Nations Development Program) project in 1972 largely through the inspiration and energy of its present director, Prof. A.R. El-Sadr. UNARC is essentially a research center although it also does a limited amount of post-doctoral training. The primary objective is "to create a centre of excellence where teams of scientists plan and execute research toward developing a national scientific base." This quotation was taken from a brochure on the organization and administrative structure of UNARC. There is no permanent research staff. Scientists from the University of Alexandria (UA), from other Egyptian universities, and from abroad are given grants to spend a few years at UNARC on specific research projects. The UA faculty members divide their time between research at UNARC and teaching at the University. Since its beginning, the Centre has received the bulk of its support from UNESCO but this ended in April 1980. There are hopes that subsequent funding will come from UA, the National Academy of Sciences (NRC, Egypt), and possibly also from contract research.

On the organizational level, UNARC is not unlike research centers in the western world. On the operational level, it is quite something else. The lack of material resources often determines how research is conducted. This became clear to us from talks with Prof. V. Sabat (Faculty of Science, UA) and a post-doctoral student, Dr. S.M. Zourab, about their work in colloid science. They are investigating the adsorption of insulin, β-lactoglobulin and myoglobulin at oil/water interfaces by examining their behavior as emulsifying agents for parafin oil in water. Their measurements include zeta potential, particle size, rate of coalescence, interfacial elasticity, and interfacial tension. They have found nothing unusual; the interfacial configuration of the adsorbed specie is as expected from their size and charge. What is remarkable is that they (i.e., Zourab) built nearly all of their equipment including a very accurate rotating-disc interfacial viscometer.

Reagents are another problem. The planning of a research project can be strongly influenced by whatever chemicals are available at the lowest cost. For example, one phase of the work on bio-surfactants at methylbenzene-water interfaces ended when the supply of anisole and zylene gave out. This problem can be somewhat averted by collaborating with an organic chemist. For example, Sabat and Zourab are working with Dr. A.A.B. Hazzah (Faculty of Pharmacy, UA) who synthesizes some unusual quaternary nitrogen surfactants containing groupings of 4 to 5 conjugated ring structures (aromatic and heterocyclic) attached to a long-chain hydrocarbon. Unlike the usual quaternary ammonium salt surfactants, the positive charge is delocalized throughout the ring system. With so long a polar "head" this surfactant should have some interesting properties.

Dr. F.F. Assaad, who came to UNARC from the NRC in Cairo, is studying the stability of monocalcium phosphate (MCP)

fertilizer in soils. In highly alkaline soils, MCP is converted to an insoluble and thus inactive polyphosphate. Actually, the polyphosphate forms on the surface of the MCP crystals to create an insoluble layer. Assaad believes an amorphous form of MCP would not become coated and would be a more effective fertilizer. In other work on soils he is investigating the use of cationic polymers such as polyacryonitrile to control the size of soil aggregate which is optimum for water retention at 1-10 μ. Also, to alleviate the problem of overalkalinity, Assaad is investigating the ion exchange property of soils and the possibility of using chelating agents or adsorbants such as xeolite to lower the effective calcium content.

We visited the Egyptian Plastics and Electrical Industries Company on the southern fringes of Alexandria. This company, which began as a plastics molding concern in 1938, is now publicly owned (under the Ministry of Industry—about half of Egyptian industry is nationalized), employs 3500 people, and includes the manufacture of polyvinyl chloride, carpeting and wallpaper, and starter batteries for automobiles, as well as plastics molding. We toured the carpet and wallpaper operations and the molding plants.

By western standards the buildings were less than modern and the equipment somewhat outdated. As the day progressed, however, we saw evidence, at least among management, of a very positive attitude to do the best possible job under the circumstances. This was the impression we received while talking with Mr. Hazem El-Khuly, the general manager of the plastics plant and two shop managers, Mr. Aloa E. Dabahg and Mr. Omar El-Barrade. The latter two were chemists by training.

Despite the well-worn equipment (we saw a wire coater that would be proudly displayed in any industrial museum in Europe) repeated repair and ingenious improvisation keeps production flowing. Dabahg indicated that there was a severe limit on the size of articles that can be produced. For example large plastic drums are out of the question. In addition, Dabahg stated that there was a severe lack of raw materials. Caprolactan is too expensive as a source of nylon and they are looking for a less expensive material. On the plus side, they have just received new injection molding equipment from West Germany as part of an economic assistance program.

The day at the Egyptian Plastics and Electrical Industries ended with a talk with the chairman, Dr. F. Garrana. Upon learning that we had visited UNARC the day before, Garrana expressed the viewpoint that there is a wide chasm between university research and industrial needs in Egypt. In his opinion Egyptian scientists do not often relate to industrial problems. This attitude was in distinct contrast to that of El-Sadr. Indeed, while we were at UNRAC, El-Sadr was hosting a group of Egyptian industrialists in order to acquaint them with the activities at UNARC and to establish more positive contacts. Shortly before that, in April, 1980, a team of American scientists from academia and industry spent a week in Alexandria visiting UNARC and different industrial firms to try to establish a policy for better interaction between UNARC and private industry.

The University of Cairo is one of the largest educational institutions in the Arab world. It has a student body of more than 140,000. The buildings that make up the University, although in various stages of disrepair, all date from the present century. Most of the professors and associate professors were trained outside Egypt, the majority in Europe but some also in the US, Canada, and Russia. Their salaries are extremely low. As a consequence most staff members take outside contracts to augment their salaries. Contracts at Egyptian universities differ from those at European universities in that the former support staff members rather than students.

One might get the impression that the quality of research at Cairo University is quite poor. This does not appear to be so, at least not in any general sense. Foreign-trained staff have an excellent base of knowledge and can develop critical masses required for excellent theoretical studies; moreover, by working closely with European universities they gain access to equipment not available in Cairo.

The Faculty of Engineering was the largest faculty in the University with 10,000 students of whom 1,400 were postgraduates. In comparison, the Faculty of Science was considerably smaller, with 3,000-4,000 students. There is a 5-year course leading to the BSc in engineering after which an MSc can be obtained in 2 additional years and a PhD in a third year. In the Faculty of Engineering, several departments have more staff members that are warranted by the number of students. As a result, throughout the faculty generally, 25% of the staff are on sabbatical at other universities in other countries. This is especially the case in the Department of Mining and Metallurgy and Petroleum which has about twice as many faculty members as students. Of the 20 staff members in this department, 10 are in Cairo, the other 10 are abroad, and only 2 of the latter group are expected to return.

Our principal contact with the Faculty of Engineering was Prof. G.S.A. Shawki, who heads the Department of Mechanical Design and Production Engineering. The principal areas of research in the department are in tribology, corrosion, and plastics fracture. Much of the work in tribology has been done in connection with brake linings. Researchers in this department developed a finite element analysis to investigate theoretically failure mechanisms of linings with emphasis on the role of the fracture toughness of the lining material. There has been very little experimental work done, however, to verify the analysis.

A universal disc machine for elastohydrodynamic lubrication studies was built by the department for the Egyptian Air Force. It is a disc-on-plate configuration and the oil thickness is determined by capacitance measurements. It is currently being used to determine the optimum grease loading for ball bearings.

Much of the work on brake linings was done by Dr. M.G. El-Sherbiny, a well-educated and extremely energetic young scientist. His present activity is in the area of corrosion; specifically, formation of anticorrosion protective layers by ion plating. Ion plating involves the deposition of metallic ions at relatively high voltages (4-10 kV). During the plating there are two competing processes: metal removal from the substrate by ion bombardment, and metal deposition by particle implantation. By achieving the proper balance of these two processes, it is possible to obtain a very dense and adherent coating. Ion-plated coatings have better adhesion to the substrate, and are much less porous than the conventional, low-voltage evaporated coatings. Corrosion protection by ion plating appears to be better than evaporated coatings or anodization. One application of ion plating, the one that El-Sherbiny is pursuing, is the coating of titanium fasteners used in airframe structures. Galvanic corrosion between the titanium fastener and the aluminum skin can be prevented if the titanium has a protective coating, but the coating must be strong and impervious. Using ion probe techniques, El-Sherbiny has shown that a $TiAl_3$ layer 15-20 mμ thick is formed by ion plating Ti onto Al. He is presently looking at the effects of various aqueous environments on this coating and is using a 3-point bending test to determine its fatigue resistance.

El-Sherbiny has worked with Prof. D. Teer at the University of Salford (UK); it was El-Sherbiny who set up the first ion-plating facility at Salford. This facility has been upgraded, most recently by Dr. F. Salem, also a student of Teer. Essentially all of El-Sherbiny's work on ion-plating has been done at Salford, but now, with UNESCO and US Army funding, he and Salem are setting up an ion-plating facility at the University of Cairo. It is hoped that by the end of 1981 there will be four professionals working on ion plating in Cairo. An extensive experimental program is planned to produce experimental films and establish the significant processing parameters. However, analysis of the film by surface spectroscopy and by microscopy will still have to be done at Salford. The university expects the delivery of a scanning electron microscope but this is likely to be some time in the future. Also, there is some equipment for microprobe analysis and transmission electron microscopy at the Egyptian National Research Centre, but these are largely inadequate for the needs of El-Sherbiny and his co-workers.

The work on polymer fracture in the Production Engineering Department involves PVC piping and impact testing on composites. The piping is produced in Egypt. Specimens are unnotched and are stressed by internal (oil) pressurization. Researchers in the department find that Egyptian pipe is slightly more brittle than the US equivalent. They are currently determining the chemical and mechanical properties of flexible, perforated PVC drainage pipe in order to develop standards for the Egyptian Ministry of Industry.

The impact testing of composites is a relatively new program. The plans are to fabricate polyester-matrix, continuous-fiber materials where the reinforcement is the famous Egyptian long-fiber cotton which weaves into an elegant fabric renowned for its sheen and drape. The reason for using cotton fiber is not so much that it is expected to be a good reinforcement, as that it is a considerably cheaper reinforcement in Egypt than a glass or graphite fiber.

The Department of Metallurgy and Metallurgical Engineering at Cairo University is headed by Prof. A. El-Mehary. Much of the staff has been trained in Germany, Russia, and the US. There is an industrial base for metallurgy in Egypt in that there is a considerable copper and iron industry. In view of this, it is difficult to explain the lack of students in this department. The work centers around corrosion, texture effects on durability, and solidification. It is interesting to note that Dr. El-Raghy of the department and Dr. David Brandon of the Technion (Israel) are writing a joint proposal to investigate the erosion of turbines for application to helicopters. They plan to submit this proposal to the National Science Foundation in the US.

The NRC in Cairo consists of 1,700 research workers of whom 650 are PhDs, and a support staff of 1,500. It is comprised of 50 different laboratories, most of which are in Cairo. We spoke first to the director of the Technical Office, Dr. El-Saleh, who said that even though the NRC is essentially a government laboratory it gets the bulk of its funds from contract research and so has become a client-oriented research facility. Indeed, the orientation can be quite specific. For example, in Tebin and the Hellwan steel province an NRC metallurgy laboratory is being set up to serve production fields and mills. Also, a large Solar Research Center is being established and will be heavily funded.

Unlike the universities or UNARC, the NRC is relatively well equipped. For example, the central laboratory has received grants from the German government for an array of equipment including nmr, a mass spectrometer, an atomic adsorption spectrometer, a gas chromatograph, x-ray diffraction and crystallography equipment, a scanning electron microscope, and ir and uv spectrometers. However, because of the client orientation research at NRC, most of this equipment will not be available for basic research by the universities but will instead be used for application engineering.

We visited Dr. N.A. Ghanem who heads the Chemical Industry Section and who has a staff of 40 people working on polymers and coatings, leather technology, cellulose chemistry and technology, pesticides, and ceramics. This section was begun in 1962. Much of Ghanem's work has been with antifouling paints. He has synthesized and evaluated organo-tin polymers having pendant tributyl tin ester groups. Besides their use on ships and because these paints form transparent coatings, they are used to protect ancient Egyptian mummies from attack by fungi. Presently Ghanem is working on triphenol-tin fluoride type antifouling paints and is developing various formulations. We discussed some of the problems associated with water/paint interactions associated with antifouling coatings. Ghanem noted that these interactions are unique for each locality; Alexandria Harbor which is continually flushed by tidal action represents a much different environment than the relatively stagnant Suez Canal. In talking about the Suez, Ghanem said that there is very significant copper contamination of the sediment in the Canal (>500 ppm). This may have an effect on the marine biology of the Mediterranean. This problem and similar problems point to the need for non-copper antifouling paints. According to Ghanem, tin-based paints are even worse. In his opinion the solution is some form of physical repellency and he is working on coatings that, by a reverse osmosis membrane mechanism, develop a high ion concentration at the paint/water interface which repels larvae. He indicated that early results of tests in the Alexandria Harbor were encouraging.

Looking to the future, Ghanem is especially interested in the radiation curing of polymers. At present he has access to a gamma ray (Co-60) source and the Radiation Center of the NRC and is planning to obtain a linear electron accelerator. (Willard D. Bascom and Robert F. Quattrone [USARSG])

POLYMER SCIENCE IN SPAIN

Much of the scientific research in Spain is contained within the Consejo Superior de Investigaciónes Cientfficas (CISC: Council for Scientific Research), a government organization which comprises a number of specialized institutes. In this report I describe three of these institutes in which there is a significant amount of polymer research: two are in Madrid, the third is in Barcelona.

I should mention at the outset that the industrial community in Spain gives relatively little support to polymer research, because most of the chemical and plastic companies in that country are multinationals which conduct their research in separate laboratories located elsewhere in Europe or in the US. There is a growing plastics industry in Spain, however, and the CSIC has very definite research programs to support that industry.

The Instituto de Plásticos y Caucho (IPC: Institute of Plastics and Rubber) in Madrid is the only CSIC institute devoted entirely to polymer research and technology. IPC directs about 30% of its efforts to fundamental research, 40% to applied research, and the remainder to development. It has a staff of 76 professionals, 32 of whom have PhD degrees.

My host at IPC was the director, Dr. J. Fontán, who explained that the work at the institute is divided into the solid-state physics of polymers, synthesis and characterization, and plastics technology, with emphasis on the processing of plastics and rubbers.

Funding comes from both government and industry. The government provides salaries and about 25% of the research money; the remaining 75%, for research and development, comes from industry, either through direct grants or through industry-government cooperative programs. These programs involve cooperative

research ventures by government and industry that were inaugurated by the Spanish government in an effort to stimulate innovation in industry. In the event that these ventures are successful and lead to increased profits (through new product development or reduced production costs) industry repays the government its share of the venture over a 5-year period. When these cooperative programs involve the polymer industry, IPC's usual contribution is to provide special testing and expert advice.

In addition to his duties as director Fontán has two special interests: polyvinyl chloride (PVC) and polycondensation reactions. For many years he has been studying the fundamental chemistry of the thermodegradation of PVC, especially the effects of UV radiation and tacticity (intermolecular arrangements). This work is partially funded by Solvay (Brussels) as well as by CSIC.

In the area of polycondensation reactions, Fontán has been investigating the synthesis of polymers with high thermostability. This stability is achieved by the introduction of aromaticity (ring structure) into the chain. Fontán has developed low-temperature synthesis procedures for a variety of polymers comprised of aromatic and polyimide groups with oxygen or aliphatic linkages. Polycondensation involves the formation of polyanhydrides which have good thermostability (400°C in N_2 atmosphere) but are unacceptably sensitive to degradation by moisture. Nonetheless, the advantage of low-temperature polymerization justifies this line of research since the present commercial high-temperature polymers, e.g., the polyimides and polyamide-imides, require high-temperature processing. At the present time, Fontán and his team are working on polyester-polyimide materials which he believes will be placed into industrial production within the foreseeable future.

IPC is conducting major research and development programs relating to polymer-modified concrete and the use of the mineral sepulite as a replacement for carbon black in rubber. The work on polymer-impregnated cement is being done in cooperation with the Instituto Eduardo Torroja de la Construcción y del Cemento (IET, Madrid). The modification procedure involves impregnating the cast cement with a vinyl-base monomer and an initiator which is then polymerized by heat *in situ*. The polymer-modified material is 35 times stronger in compression and 3 times higher in tensile strength and tensile modulus than unmodified cement. Moreover, polymer impregnation reduces the equilibrium moisture absorption by a factor of 10 and increases abrasion resistance by a factor of 5. Although polymethylmethacrylate (PMMA) is the cheapest of the vinyl polymers, it is an unsatisfactory candidate because the relatively low glass-transition temperature (T_g) of PMMA (105°C) causes the polymer composite to exhibit a dramatic loss in strength above 100°C. Cements modified with other methacrylate polymers with higher T_g, such as a PMMA-allyl acrylate copolymer, retain strength to higher temperatures, but the cost is substantially increased. Polymer-modified cements are intended for use in prefabricated structures, but the high cost of this material developed by IPC and IET may restrict it to special situations requiring high strength and durability.

Sepulite is a plentiful mineral in Spain. For the Spanish plastics industry it serves as an inexpensive filler (3¢/kg after grinding) for extending or reinforcing polymers.

IPC has a program to treat the surfaces of sepulite and silica with organosilanes and organotitanates and thereby improve them as reinforcements for elastomers. By using a mercapto-functional organosilane-treated sepulite, researchers at IPC claim that they can replace 30% to 40% of the carbon and natural rubber filler without sacrificing any of the reinforcement properties of those materials. Currently, they are investigating other fillers such as the alumino clays, and they are also studying the effects of grinding on the reinforcement properties of fillers.

In the Rubber Group of IPC the work on inorganic fillers for elastomers is directed by Dr. J. Royo. Much of this group's effort involves contract work for industry; it is also attempting to develop standards for plastics and rubber for the Spanish Government's Department of Standards (IRANOR: Instituto Racionalización y Normalización). Currently, Royo is conducting fatigue tests on rubbers. The data scatter in this type of testing is so great that it is customary to state only the mean lifetime together with the ratio of the longest and shortest lifetimes recorded, but this does not give any indication of confidence limits. Royo tried fitting fatigue data to various distribution functions, e.g., Gaussian, log-normal, and Weibull, and found that the Weibull distribution was quite satisfactory.

Dr. J.G. Fatou heads the Physical Chemistry Group which has been involved for the past 5 years with a fundamental study of the thermodynamics of polymer crystallization and crystal conformation. Fatou's group, which has worked on polyethylene, polypropylene, and polyisobutylene, currently is investigating the low-molecular weight polyoxides

$(-[(CH_2)_m-O]_n^-$, where $m = 2,4,6,8,10,12$). These researchers are able to describe the crystallization of the polyoxides in terms of the free energy for nucleation. Their studies include the effects of thermohistory on crystal morphology, crystal-crystal transformations, and the role of the melt viscosity. Fatou believes that the low mobility of polymer molecules around the crystalite influences and indeed inhibits growth even after long annealing.

The Physical Chemistry Group is also involved in the dynamic mechanical testing of polymers. This work is under the direction of Dr. J.M. Preña. The instrumentation includes a rheovibron, a rheogoniometer, and equipment for rheocapillarity measurements. Preña has studied drawn polyethylene (draw ratios of 1:10) and a polyimide ([4, 4' aminophenyl ether pyromellitimide]): the latter exhibits secondary transitions at -68°C (110 hz), which can be attributed to absorbed water, and at 120°C (110 hz), which Preña attributes to oscillations of aromatic rings linked to oxygen.

The Instituto de Estructura de la Materia (IEM: Institute of Material Structure), which is also part of CSIC, was established in 1975. IEM is divided into departments of particle physics, quantum chemistry, molecular spectroscopy (mostly nuclear magnetic resonance), molecular physics (mostly Raman spectroscopy), and macromolecular physics. My host at IEM was Dr. Baltá Calleja of the Macromolecular Physics Department. He uses his full name, (Spanish names include both the paternal and maternal families) to avoid confusion with his father, Prof. Baltá, a well-known Spanish educator. Many Spaniards use only the paternal family name, e.g., Fontán's full name is Jose Fontán Yanes.

Baltá Calleja's research is devoted almost entirely to the microstructure of crystalline polymers and the relationship between crystal structure and physical properties. In his work he uses wide- and small-angle x-ray scattering (WAXS and SA SAXS), infrared spectroscopy, magnetic susceptibility measurements, and microhardness measurements. He is especially interested in the effects of chain defects, i.e., short chain branching, unsaturation, or the presence of unreacted monomer on crystal conformation. One of the questions posed by the presence of these effects on the polymer chain is whether they are included within the crystal structure or tend to concentrate at the surface of the crystal. Baltá Calleja has found, as have others, that these defects are accommodated by kink formation within the crystal structure and that the amount of defect accommodated within the lattice depends on the amount and size of the chain defect, the mode of crystallization, and the extent to which the sample has been deformed mechanically. In his studies of the crystallization of linear and branched polymers, Baltá Calleja has found that the observed cell dimensions and lamellae thicknesses can be interpreted best in terms of microparacrystals, i.e., crystals that consist of mosaic blocks with liquid-like distortions. In addition to his study of crystal dimensions, he has been investigating the effects of lattice defects. on polymer conductivity and magnetic susceptibility.

Microhardness measurements are an important part of the work of the macromolecular group at IEM. In their early studies (1976), Baltá Calleja and his coworkers showed that the microindentation hardness of polyethylene (PE) is a function of crystal thickness and amorphous content. In subsequent work with Dr. D.C. Bassett (Univ. of Reading, UK) on slightly drawn PE (draw ratios of 1:10) and with Dr. R. Porter (Univ. of Massachusetts, Amherst) on highly drawn, ultrahigh modulus PE, they were able to relate microhardness measurements with the anisotropy of the drawn PE. Moreover, they have found that this anisotropic behavior is time-dependent and thus reflects the viscoelastic nature of the polymer, and that the measurements also reflect the sheet-core structure of ultrahigh modulus PE.

The work of the Macromolecular Group at IEM includes studies of the structure of biological membranes: the structure of brain lipids (cerebrosides) by means of SAXS and tests for diamagnetic susceptibility. They have also worked on the selective etchings of polymer crystals, using fuming nitric acid as a means of differentiating crystalline from amorphous regions. Finally, Baltá Calleja is collaborating with Prof. M. Kryszewski (Univ. of Lotz, Poland) in studies of the conductivity of linear polymers and in finding means of doping PE to form semiconducting materials.

Not all the polymer research in Spain is done in Madrid. In Barcelona there is a small group of polymer researchers in the Departamento de Química Macramolecular (DQM: Department of Macromolecular Chemistry), in the Escuela Técnica Superior de Ingenieros Industriales (Technical School for Industrial Engineers). The DQM is a CSIC laboratory, headed by Prof. J.A. Subirana, which was moved from a genetics department where its work was entirely devoted to biopolymers, to the engineering department of the escuela. This move was designed to involve the group in research on synthetic polymers in order to assist (and get financial support from) the Spanish plastics industry. At present all of Subirana's funding is from CSIC.

Ninety percent of the work at DQM is still related to biopolymers, specifically, the microstructure of biopolymers. Their mainstay is x-ray diffraction and my guide through the laboratory, Dr. Sebastián Muñoz Guerra, showed me no less than five x-ray diffraction machines (WAXS and SAXS) in operation. Muñoz Guerra also showed me the "map room" where structural models are correlated with complex diffraction pattern data. In addition to x-ray diffraction work, the DQM Group uses chromatography, electron spectroscopy, an amino acid analyzer, and a preparative ultracentrifuge in their studies of polymer structures. In the use of electron microscopy, the DQM Group has developed a method of embedding specimens in polyvinyl alcohol that does not destroy the lipid structure as usually occurs with conventional embedding methods. The group is working on polyacrylamide embedding agent that preserves crystal structure. The chromatography testing includes gel permeation, ion exchange, and high-voltage paper electrophoresis. The high-voltage paper electrophoresis technique is used to obtain good separation of large polypeptides and protein molecules which cannot be obtained by conventional, low-voltage electrophoresis.

Much of Subirana's investigating work has been directed to proteins from marine organisms. Most recently he and his group have been studying the basic proteins in the spermatozoa of Salonmid fishes. This work is continuing along with studies of the interaction of short peptides (protamines) with DNA.

The initial excursion by DQM into synthetic polymers has been rather modest thus far. DQM researchers are studying the effect of nucleation on the crystal structure of PE, and the synthesis and structure of polyamides (nylon). They feel comfortable working with polyamides in view of their close resemblance to polypeptides.

The amount of polymer research in Spain is modest in comparison with that being conducted in other European countries of comparable size. Nonetheless, the work is in the mainstream of basic polymer science and plastics technology. In addition, there seems to be a clear commitment on the part of the CSIC to develop a technological base for the fledgling plastics industry. (Willard D. Bascom)

MEDICAL PHYSICS

NEUTRONS, NUCLEAR POWER AND RADIATION SAFETY—IN ITALY

For the student of the history and development of energy derived from the nucleus, Italy has a special place. Despite the earlier work of James Chadwick of the UK ("Possible Existence of a Neutron" [*Proc Roy Soc*, London A136:696, 1932]), and the Joliot-Curies of France (who discovered artificial radioactivity in 1933), it was Professor Enrico Fermi and his colleagues in Italy who first observed nuclear fission and also induced man-made radioactivity by neutron bombardment ("Possible Production of Elements of Atomic Number Higher Than 92" *Nature*, London, 133:898, 1934; "Radioactivity Induced by Neutron Bombardment" *Nature*, London 133:757, 1934). Of course the explanation of the process of fission was not forthcoming until 1939, when it appeared in articles published by Lise Meitner and Otto Frisch (working in the UK), and also by Hahn and Strassmann.

By 1938 Fermi had come to the US (with his Nobel Prize in Physics for the pioneering work with neutrons). He was a major figure in the team that successfully built and achieved the first controlled neutron chain reaction in 1942 at the University of Chicago. This first nuclear reactor was the forerunner of the large nuclear power reactors that were built in later years.

What is the status of the Italian nuclear power program? At this time it has come to a virtual standstill. How did this situation come about? The information that follows was obtained from senior scientists at the Comitato Nazionale Energia Nucleare (CNEN: National Committee For Nuclear Energy), a government agency in Italy.

Italy presently has three operating nuclear power reactors, all over 10 years old. They are located at Garigliano (Caserta), about 200 km south of Rome; at Latina, some 70 km south of Rome; and at Vercelli, near Turin, about 600 km north of Rome. The power output (electrical) is in the range 200 to 250 MWe (megawatt, electrical), which is not large in comparison with power reactors planned or being built in other European countries. Two additional reactors with larger planned outputs are in construction; one at Caorso (Cremona), on the Po River (∿800 MWe), the other at Montalto di Castro (∿1000 MWe). The completion date for the latter is estimated to be at least 5 years away.

General responsibility for developing energy sources belongs to CNEN. The magnitude of the problems confronting that organization can best be understood from an examination of the current sources of energy on which Italy depends. About 70% of Italy's total energy needs are met by oil, all of which is imported from the Middle East, Venezuela, and Mexico. The remaining 30% comes from hydroelectric power, and from coal purchased from Poland and South Africa, which is actually cheaper than coal mined in Italy. Some thought is being given to the possibility of obtaining gas from Algeria or Tunisia through a pipeline which would be built under the Mediterranean Sea. Parts of North Africa are less than 100 km from the nearest Italian coastal region.

In view of this considerable dependence on costly imports for energy, CNEN embarked many years ago on a long-range program for planning and constructing nuclear power stations. Laws were promulgated to insure appropriate and safe procedures for the construction and operation of nuclear power plants with adequate safeguards against nuclear accidents and also against danger to health from radiation. The first law passed in Italy in 1962, provided general authorization for the construction of industrial nuclear plants, and for the treatment and use of minerals, special fissile materials of enriched uranium, and other radioactive materials. The responsiblity for planning nuclear plants designed to produce electricity was assigned to a National Board for Electric Power (ENEL). This Board in turn was to follow the nuclear program for production of electricity which would be established by the Interministerial Committee for Economic Planning (CIPE: Comitato Interministeriale per la Programmazione Economica).

A crucial part of any country's planning for the production of electricity from nuclear plants is the matter of siting—where shall the plants be located? It was precisely this aspect that Italy found troublesome. The Italian government ultimately solved the problem by passing laws which took into account the regional and local governments. These laws provided that ENEL would prepare programs subject to the approval of CIPE that determined the region on whose territory the power stations were to be placed. Thereafter it became the region's responsibility to find at least two areas within its territory that were suitable for the installation of nuclear power plants, with technical advice and approval from CNEN. ENEL then had the obligation to perform the appropriate geological and environmental studies for the proposed sites, leading to an actual site choice. This somewhat complex procedure for site selection appears to give local authorities in Italy a practical veto power over the location of nuclear power plants within their territories.

Another aspect of the problem is the fact that despite the successful and safe operation of the existing nuclear power plants for over 10 years, opposition to the siting and construction of new nuclear plants has been developing during the past 2 years. In some ways this parallels similar movements that have developed in other parts of the world, particularly in the West. Such opposition can be understood in terms of the concern that many people have about the detrimental effects ionizing radiation can have upon health. In Italy, however there appears to be an additional political factor. Opposition to the construction of nuclear power plants is an official stand taken by one of the small radical parties in Italy. Although its numerical strength is not large (only 2 to 3% membership in the Chamber of Deputies, the legislative body in Italy), this party has been quite influential in stopping new construction. Its members have been successful in persuading local residents to oppose siting studies in their neighborhoods. While it is dangerous to generalize, it is thought that many young people and "environmentalists" have supported opposition to nuclear power.

Widespread publicity about the events at Three Mile Island have increased people's concern about nuclear safety. Another factor is the problem of long-term storage of radioactive waste products.

It is interesting to note that few people have expressed similar concerns about the public health hazards associated with alternative fuels. For example, the burning of coal has not aroused fears about public safety. (This is true even though the release of sulfur and small quantities of radium as a consequence of burning coal may have adverse health effects.)

Some European countries have turned to referendums to determine whether people are for or against nuclear power. Such votes have taken place recently in Sweden and in Austria. To the surprise of many (including the Swedes) the Swedish vote reflected a cautious approval to go ahead with nuclear power, but with appropriate safeguards. A vote in Austria on a "Yes" or "No" basis brought a negative response. This was especially interesting because a nuclear power plant had already been constructed in Austria, and the purpose of the voting was to decide whether or not to put the plant into operation. Ironically, a nuclear plant recently completed north of Zagreb (Yugoslavia) is

closer to Vienna than the Austrian plant which received the "No" vote. (Scientists in Zagreb "explained" to me that the Viennese had nothing to fear from the Yugoslav nuclear reactor since the "Iron Curtain" would absorb any radiation emitted.)

It is helpful in discussing the effects of ionizing radiation on a community to consider some kind of yardstick. This can be provided by noting the radiation levels to which a population is exposed by background radiation and by the use of radiation in medical and dental examinations. (One should also add that the use of radiation for medical purposes has a well understood and documentable beneficial aspect.) The 1980 estimates of these quantities for Italy were supplied by Dr. Antonio Susanna, a senior scientist on the staff of CNEN.

I. Background Levels

External		
cosmic rays	36	mrem/yr
terrestrial	63	"
buildings	13	"
	112	"
Internal (body)		
K^{40} plus other nuclides	18.5	mrem/yr
C^{14}, induced by cosmic rays	1.5	"
Radon	∿15.	"
U, Th	2.	"
	37	"
TOTAL	149	mrem/yr

II. Medical Diagnostic X-rays ∿ 76 mrem/yr

III. All other Sources
fall-out, plane flights < 18 mrem/yr

These "yardstick" numbers can give some perspective to the exposure doses an individual or a population may receive either from a voluntary act or from a nuclear accident. One illustration is offered for each by way of example. On the one hand, a person flying in a modern airplane from Los Angeles to Washington, DC, receives an exposure dose of 2 to 3 mrem. On the other, a conservative estimate based on ground-level radiation measurements from thermoluminescent dosimeters, for the average individual radiation dose received by approximately 2 million persons residing within 50 miles of the Three Mile Island Nuclear Station, is 1.5 mrem.

It is plain that the final chapters for nuclear power in Italy (and other western countries) have not yet been written. The complexities of societal needs for energy and the strong concerns for health effects on whole populations insure that the debate and decisions on nuclear power will continue for a long time. (Moses A. Greenfield)

NEXT IN ITALY—MEASUREMENT OF X-RAY EXPOSURE DOSE

Italy shares with all other countries that use ionizing radiation for beneficial purposes the same desire to provide maximum benefits with minimum risks. This is especially true in the use of X-rays that provide useful medical diagnostic information. The responsibility for licensing and inspecting X-ray machines in Italy belongs to the Division of Environmental Protection (DEP), a unit of a much larger governmental agency called the Comitato Nazionale Energia Nucleare (CNEN: National Committee for Nuclear Energy). One of the senior scientists in the DEP is Dr. Antonio Susanna, who was the source of much of the information in this report.

For the community of nations, recommendations regarding radiation exposures have been made over the years by the prestigious International Commission on Radiological Protection (ICRP). However even the ICRP does not consider it practical to define precise limits for radiation exposure doses for medical usage, either diagnostic or therapeutic. The complexities and the varied strategies in the use of X-rays, which may differ widely in a given country as well as between countries, make it truly impractical to define specific limits. This does not mean, however, that because of such factors as poor supervision or faulty equipment or components there may not be excessive amounts of radiation used on occasion. Furthermore, inadequate quality-control programs either for the X-ray machines or the photographic processes used to develop radiographic films often lead to the production of films with diminished diagnostic value (lessening of the benefit in the risk-benefit balance).

For the above reasons, it is important that national surveys be made to evaluate the performance of X-ray machines with regard to both the patient exposure dose and the quality of the X-ray beams. Such surveys permit the estimated radiation exposure doses from medical diagnostic examinations conducted in a particular country to be compared with those found in other countries. They also assist in revealing abuses and oversights, and provide a basis for taking corrective measures.

The first truly national survey in Italy of the radiation exposure patients were subjected to in medical diagnostic examinations was undertaken by the CNEN in cooperation with another governmental agency, the Istituto Superiore de Sanità, (ISS; National Institute of Health) in 1974. The results were reported in 1977.

The data collected reflected about 10% of the X-ray examinations carried out in the year covered by the survey. Despite the problems created by sampling difficulties, incomplete forms, and approximations of various kinds, a very crude estimate was obtained of the genetically significant gonadal dose (GSD) received by the Italian population due to X-ray examinations. GSD may be defined as the hypothetical dose which if delivered to the gonads of the entire population would have the same genetic consequences as the actual distributed population dose. The estimate was 30 milli-rems (mrem), comparable to similar data for other industrially developed countries. Perhaps of greater consequence was the information gathered about the widespread use of X-ray examinations. It was estimated that 24 million examinations took place in a total population of 55 million persons. Some 4 million of these examinations were dental X-rays. The conclusion was that for each 1,000 of population some 435 persons received X-ray examinations, 72 of which were dental.

Susanna and his colleagues were seeking a better vehicle for carrying out a national survey, and they decided that the NEXT program would best suit their needs. NEXT, which is an acronym for Nationwide Evaluation of X-ray Trends, designates a program developed by the US Bureau of Radiological Health. It is aimed at collecting information on various techniques used for 12 selected radiological diagnostic examinations.

In a NEXT survey a technologist at the local facility is requested to set out the X-ray examination as if he or she were going to perform the most frequently used examination for a patient of average size (height, weight, and body thickness). The NEXT inspector records information about the facility, the workload, and the technologist's training. In addition, the inspector records the specifics of the X-ray technique employed (kilovoltage [kvp] milliamperes [mA], seconds exposure [s], film size, source [X-ray] to film distance, X-ray beam size, exposure dose at a stated distance, and exposure dose rates with various aluminum thicknesses in the X-ray beam as filters). Doses are measured with ionization chambers that have been calibrated at a central standards laboratory. The measurements permit the calculation of the skin entrance exposure dose, the gonadal dose and the X-ray beam quality expressed as a half value layer (the half value layer ≡ the thickness of aluminum required to reduce the X-ray beam to half its intensity).

Each place visited is given the data obtained for it as well as the data for the mean values at other facilities. On the basis of these data a facility may revise a faulty procedure or detect a malfunction in equipment or in processing its films.

After an initial pilot study, the CNEN and ISS scientists presented the NEXT program to regional administrators in Italy in 1977. Since regional administrations have only recently come into existence (1975), there were a number of practical problems to be overcome. Despite these problems, however, the program was considered a great success when it was conducted in the Umbria region, which was the first region where it was attempted. After some months the Emilia regional administration decided to start the NEXT program in one of its provinces. Three other regional administrations are thought to be likely to undertake NEXT programs soon. It has been agreed that the NEXT surveys would be performed by regional operators. However the data processing and instrument calibrations would be performed by the CNEN and ISS scientists.

Table I lists early results for some of the measured parameters for some selected procedures.

TABLE I

Procedure	Voltage kVp		mA.s		B/F*		HVL Al mm	
	min	max	min	max	min	max	min	max
Chest P/A+	40	90	2	200	0.6	8.2	0.9	4.0
Abdomen A/P++	60	100	12	160	1.0	2.3	1.6	4.5
Lumbar Sacral Spine A/P	55	100	20	200	0.9	3.5	1.5	5.0

*B/F = ratio of beam area to film area
+P/A = posterior-anterior
++A/P = centrum-posterior

What is noteworthy is the enormous range of values, from minimum to maximum, of such parameters as (mA)(s) with a ratio of 100 to 1 for the chest (P/A) examination. Equally noteworthy (and disconcerting) is the large variance in beam area to film area from 0.6 to 8.2, again for the chest (P/A). The ratio 8.2 (maximum value) suggests that virtually no collimation was used for that X-ray beam, and this implies that much of the patient's body undoubtedly received exposure. Similarly, the HVL of 0.9mm Al (chest P/A) is an unacceptably low value (with an implication of large patient dose and a poor quality film).

Table II lists the minimum, maximum and mean values for the computed skin entrance and gonadal doses (mR = milli-roentgen; mrem = milli-rem).

TABLE II

Procedure	Skin Entrance Exposure Dose mR			Ovarian Dose mrem			Testicular Dose mrem		
	min	max	mean	min	max	mean	min	max	mean
Chest P/A	8	375	56	0.5	26	3	0.5	15	
Abdomen A/P	391	3328	1222	55	644	252	1	57	13
Lumbar Sacral Spine A/P	187	3173	1311	21	538	286	0.5	46	15

Consistent with Table I listings, one may note the large divergence of values between minimum and maximum for the chest (P/A) procedure. A similar comment may be made for the other two procedures listed. It is clear that in a number of cases the patient was subjected to unnecessarily large exposure doses.

As an adjunct to the NEXT program it was determined that 90 million radiographic films were used in Italy in 1975 corresponding to an annual rate of increase of 8%. This is similar to the US rate. The estimated contribution to the GSD due to radiographic examinations was about 40 mrem. This estimate is somewhat higher than those for other developed countries. It is presumed that the major reason for the higher value was the use of large X-ray beam sizes, often considerably larger than film dimensions.

While the NEXT program has been carried out in only two regions thus far, the preliminary findings would seem to justify extending the program to other regions in Italy. When this has been accomplished, the NEXT results should effectively show local administrations where improvements are needed in radiological techniques with a consequent reduction in patient dose and an improvement in the diagnostic value of the film. (Moses A. Greenfield)

PHYSICS

BUBBLES AND BUBBLES AT THE UNIVERSITY OF GÖTTINGEN

Prof. Dr. Werner Lauterborn is one of the leading experts in underwater cavitation research, and I visited him at the University of Göttingen to learn of his work.

Göttingen is a charming university town with 725,000 inhabitants. It is situated near the East German border and lies on the fringe of the Harz Mountains. The town is more than a thousand years old but the university was founded only in 1737. It is claimed that it soon became one of Europe's most enlightened and popular centers of learning, with absolute freedom for research and scholarship for its 800 students. Today, the university has over 20,000 students and is the town's most important asset.

The Faculty of Physics, which dates from 1922, is divided into three substantially independent and autonomous institutes. Lauterborn heads the Third Institute of Physics (Drittes Physikalisches Institut) which deals with nonlinear processes. More specifically, the main interest is in underwater cavitation bubbles. The institute has a permanent staff of two PhDs and presently has ten research students. Funding comes mainly from the Frauenhofer Gesellschaft in Munich, acting for the Ministry of Defence. Other financial assistance comes from the Deutsche Forschungsgesellschaft, which corresponds to the National Science Foundation in the US. The university gives internal support in the form of computer facilities and workshops.

Hydraulic cavitation in liquids caused by mechanical disturbances was studied more than 200 years ago by Euler and is of interest today in the design of propellers, pumps, and hydrofoils. Cavitation can also be caused by a concentration of high acoustic power, and this presents limitations to sonar. Lauterborn uses yet another method, high-intensity focused laser beams, to create cavitation bubbles in a carefully controlled situation. He then studies the bubbles with high-speed photography. Many of the achievements of the Third Institute were reported at a recent conference, "Cavitation and Inhomogeneities in Underwater Acoustics," that was held at Göttingen (9-11 July 1979) but work is continuing and further developments are in sight.

Lauterborn uses Q-switched ruby laser pulses delivering about 1 Joule, with a pulse duration of 30 to 50 ns, as power sources. The beam is directed through a glass container into liquid, where it is condensed by a lens with a short focal distance and creates one or more bubbles (cavities) in the vicinity of the focus. The bubbles are illuminated by a flash lamp (the light of which is diffused by a ground glass plate) and photographed by a Beckman-Whitley model 330 rotating-mirror camera that can take photographs at rates of up to 1 million frames per second. Lauterborn's investigations show the peculiar formation of a jet upon the collapse of the bubble and confirm earlier predictions of this phenomenon. The behavior of the bubbles changes when other bubbles or solid surfaces are in proximity to them. One's perhaps misplaced sense of justice is rewarded by a pictorial example showing a small bubble shooting a strong jet at a big one that is about to engulf it.

Lauterborn and R. Timm are also studying bubble collapse photographically at 1 million frames per second. Even that they find too slow, and they are presently trying for a system giving 5 million frames per second. The main difficulty they have encountered was due to the small number of pictures available (16 in the examples that I saw) which makes it essential that the initiation of the sequence be very accurately timed. So far, successful timing has been achieved with a secondary laser system (He-Ne) passing a beam through the bubble-forming focal region of the ruby laser system. The light intensity, which is measured by a photodiode, is found to be substantially reduced during the life of the bubble but to increase sharply as the bubble size decreases. This fast rise in photodiode output is used to trigger the high-speed camera. A film showing the main results of the high-speed photographic studies may be obtained from the *Institut für den Wissenschaftlichen Film*, Nonnenstieg 72, D3400, Göttingen, West Germany, Film E2353-Lauterborn, Bolle.

Lauterborn and W. Hentschel have developed a multi-foci collimating system for generating multiple bubbles. They use a computer to generate what they refer to as digital holograms, giving a lens with an aperture distribution that is simply the vectorial addition of the distributions required for the formation of each of the several foci. Amplitude variations are ignored (equivalent to hard clipping), and a non-lossy, phase-only correction is realized with a glass substrate and photographic processing (photoresist layer). The use of phase only causes some side lobes but produces only a small decrease in gain (about 1 dB).

The dynamics of clusters of bubbles are being studied in three dimensions with high-speed holocinematographic methods developed by Lauterborn, K.J. Ebeling, and K. Kuhnke. These scientists successfully developed several different methods. One of these, their standard method, uses two ruby lasers. The first laser is focused as before to induce breakdown in the liquid and to generate bubbles. The second laser is used to illuminate the bubbles through a diffusing plate and provides the holographic reference beam. It is Q-switched and produces up to eight 30 ns-long pulses. Lenses are used to magnify the image for better resolution. Different small portions of the holographic plate are sequentially exposed through apertures of a fast-rotating disc positioned directly in front of it, in such a manner that each pulse illuminates another portion of the plate. Rates of 30,000 holograms per second have been achieved. A continuous He-Ne laser is used to reconstruct the pictures, illuminating the exposed areas of the plate one by one. Each hologram is examined for different image planes.

G. Haussmann and W. Steinhoff, working with Lauterborn, use digital processing holograms to size and count bubbles in cavitation bubble fields. The bubbles are obtained as before or from real-life situations rather than by laser-generation. The hologram is used to reconstruct the three-dimensional bubble field using an ion laser, and the field is examined with an image-dissector camera (EMR Schlumberger) with optical data digitizer. The output goes to a computer which in turn controls the camera position in the x,y, and z directions. Single bubbles are found and focused with digital picture processing techniques in which a local gradient operator sharpens the contrast and permits the detection of the edges of the bubbles. This procedure requires the use of special noise-suppression techniques. The sharpness of the edge of the bubbles is used as a criterion for finding the depth positions of the bubbles and for determining their size.

When the sound intensity in a liquid exceeds the cavitation threshold, bubbles are formed and a noise spectrum is emitted. This spectrum is being studied by E. Cramer both theoretically and experimentally, by examining the response of bubbles to sound fields. Well-defined, strong subharmonics are found to exist.

In a separate research and development effort within the Third Institute of Physics, D. Guicking has investigated acoustic absorbing materials. Guicking's investigations followed original work by Prof. Meyer during WWII under the

code name "Alberich" (after the king of the Nibelung dwarfs who could make himself invisible by wearing a magical cap). In recent years this work was carried out in cooperation with the UK Ministry of Defence, but the contracts have expired and the work has been stopped. The latest configuration of underwater acoustic absorber departed from the more conventional form of rubber with cavities. It was more like a lump-constant device built with mechanical springs that were wound on air-filled plastic tubes, about 1 cm in diameter, and then cast in silicon resin.

Lauterborn plans to continue his studies of cavitation. In particular, he expects to improve his high-speed cinematography and to achieve 5 million frames per second which is the rate he considers ne necessary to study the decay of bubbles properly. A new subject that he wants to tackle is the study of solitons which, I am told, are non-dispersive waves in nonlinear systems. (Theodore C. Cheston)

THE FIRST EUROPEAN PHYSICAL SOCIETY "SOLID STATE" MEETING

The annual solid state meeting of the American Physical Society is called the "March Meeting" even though it may not be held in that month. This year the meeting was held on 24-28 March 1980 in New York City and was huge by any reasonable standard—featuring a minimum of 12 simultaneous sessions running for 5 days, presumably leaving the attendees little time to enjoy the delights of the city of New York. In the same spirit, the European Physical Society held a meeting of the Condensed Matter Division on 9-11 April in Antwerp, Belgium featuring eight simultaneous sessions running for 2 1/2 days.

As a result of the larger than expected attendance the meeting was belatedly moved from the Euro Crest Hotel in Antwerp to the University of Antwerp. Consequently a group of us who had made our way to the hotel were late for the first session. Mail in Europe is sometimes slow and thus I found the announcement of this last meeting change in my mailbox on my return to London. The meeting was probably as notable for its form as for its content and it is the form on which I will concentrate in this report.

A general opening session was held late on the morning of the first day. Following a brief welcome by Dr. R. Clara, the Rector of the University of Antwerp, the group was addressed by Prof. M. Balkanski of the University of Pierre and Marie Curie (Paris, France), who is chairman of the Condensed Matter Division (CMD) of the European Physical Society (EPS). Balkanski said that this meeting was the first general "March Meeting" to be held in Europe, since theretofore there had been no European equivalent of the annual Solid-State Meeting of the American Physical Society. He expressed pleasure with this development since it meant that now a young scientist could present his work to a relatively large group without going overseas. Also he noted that all of the Russians invited had declined the invitation.

Prof. J.T. Devreese of the University of Antwerp, who organized the meeting, also addressed the group, pointing out that previous meetings of the CMD had emphasized topical conferences. After a promising start in 1971 the conferences, held every three years, were not uniformly successful (only 80 participants attended the 1977 meeting). Consequently he had organized this conference with some misgivings but had persevered because he was convinced of the need for a regular meeting to serve the 7,000 solid-state physicists in Europe. Devreese strongly favors conferences of this type patterned after the "March Meeting" of the American Physical Society to serve all aspects of solid state physics. He would prefer it to be organized as a European meeting across national boundaries rather than as one which would coincide with the meeting of a national physical society. That is, he firmly believes that the CMD can only be effective as an international meeting. Devreese also requested that the CMD send an observer to attend the organizational conference for the next March meeting of the American Physical Society. He concluded by expressing the wish that much cross fertilization between different fields of physics would occur at the present gathering.

Organization was such that the sessions were of several formats: Plenary, invited papers, invited and contributed papers, and contributed papers. Of course all of the 6 plenary session papers were invited, 3 of them from the US. Of the other 51 invited papers, France and West Germany accounted for almost half (23) with the rest spread over the other western European countries plus Yugoslavia, Hungary, Poland, Israel, Japan, and the US.

Of the 311 contributed papers a large number (43) had authors from two or more countries. These multinational papers occurred mostly from collaboration on theoretical calculations or as a result of utilizing some large facility such as the muon source at CERN (Switzerland), the synchrotron radiation source at the Project for the Utilization of Synchrotron Light (PULS) in Italy, and

neutron sources in the US, Canada, and France. Considerable multinational cooperation also occurred in optical experiments, principally Raman and Brillouin scattering.

The invited speaker at the general opening session mentioned above was Prof. M. Cardona of the Max Plank Institute in Stuttgart, FRG, who spoke on amorphous silicon and amorphous silicon with hydrogen. Cardona said that amorphous silicon is quite easy to prepare and can be made inexpensively. The samples are thin films prepared by vacuum evaporation, sputtering in an argon atmosphere, or glow discharge deposition. All three processes make thin films of amorphous silicon which, unfortunately, are difficult to dope with hydrogen. The hydrogen, which is important in determing the electrical properties, can be introduced by sputtering with various additives or by introducing PH_3 (→ n type) or B_2H_6 (→ p type) into the SiH_4 gas used in the glow discharge. Amorphous silicon containing 10-15 atomic percent hydrogen can be manufactured using these processes.

Addition of impurities to crystalline semi-conductors shifts the fermi level and similarly with amorphous silicon the introduction of hydrogen brings the fermi level down, near, or into the valence band. In intrinsic silicon, infrared absorption is prohibited and Raman processes are allowed for only k=0 because of symmetry. However, these rules are not necessary in amorphous silicon and its infrared absorbtion spectrum is correspondingly changed. When hydrogen is introduced into the silicon, the hydrogens tend to cluster in groups of four because four hydrogens can substitute for one silicon. These clusters result in localized modes for the four hydrogen atoms which are evidenced as infrared absorption lines.

Since hydrogen affects the semiconducting properties, determining the amount present is an important measurement. Measuring this amount by evolution of hydrogen is destructive, and infrared absorption is used instead. The absorption can be calibrated by a nuclear method in which the film is bombarded by a beam of nitrogen atoms producing the reaction

$$^{15}N(6.4\ MeV) + {}^{1}H \rightarrow {}^{12}C + \alpha + \gamma(4.4\ MeV)$$

The number of emitted gammas is proportional to the number of hydrogens present so that counting the gammas gives a determination of the hydrogen present. The presence of SiH_2 is believed to be detrimental to achieving high levels of hydrogen doping. Its presence can be characterized by the strength of the infrared absorption associated with the rocking mode of the two hydrogens in a tuning fork type motion.

Other interesting invited papers were presented by Dr. J.C. Phillips of the Bell Laboratories and Prof. I.F. Silvera of the University of Amsterdam. Phillips spoke on the glass transition in chalcogenide alloy network glasses and will not be reported further since his work is presumably familiar to Americans. Silvera told about his work on atomic hydrogen which will be reported soon in a separate *ESN* article.

From the evidence of the far greater than expected number of contributed papers, the growth of cooperation across national boundaries, and an attendance of over 500, solid-state physics in Europe appears healthy and the sequence of the European "March Meetings" is well-launched. (John R. Neighbours)

PHYSICS, PEACE, AND PYRAMIDS IN EGYPT—PART II

This is the second installment of a two-part article on physics programs underway in Egypt at Ain Shams, Al-Azhar, and Cairo Universities, Cairo, and at Mansoura and Tanta Universities. Even though the emphasis during my visits to these universities was on optical physics, I discussed topics ranging from solid-state to thin-film physics with my hosts.

Ain Shams University

The Physics Department, headed by Prof. F.A. El Bedewi, produces some 50 BS, 20 MS, and 5 PhD physics graduates each year. The department has a theoretical physics group, as well as the following experimental research areas: physical optics and spectroscopy; electronics; and nuclear, gamma-ray, and solid-state physics.

In the late 60s, El Bedewi, Prof. Luis W. Alvarez (Univ. of Calif., Berkeley), and others conducted a search for possible hidden chambers in the Pyramid of Chephren. The search was carried out using cosmic-ray muons, detectors (spark chambers) capable of determining the angle of arrival of cosmic-rays, and much data analysis. The research team was able to produce x-ray-like images of the central portion of the pyramid. The space searched, which comprised 19% of the pyramid's volume, was a vertically oriented cone of 35 degrees half-angle (point resting in a small chamber central to and beneath the pyramid). The investigators concluded that no chambers similar to those in The Great Pyramid of Cheops existed within the volume searched. The project had a beneficial side effect however; it resulted in the establishment of a computer center. Last year, Alvarez was invited back to Egypt to a celebra-

tion of the 10th anniversary of this center, and in the course of his visit, he received an honorary doctorate from Ain Shams University.

The Physical Optics and Spectroscopy Group at Ain Shams, which is led by Prof. Mahmoud A. Khashan, has 6 staff members who are supervising 8 graduate students. He has published several papers on interferometric techniques used in microscopy and for determining the dispersion, refractive index, and interference order in dispersive layers, as well as papers on the use of Fabry-Perot (F-P) spectrometers. He has recently developed an interferometric technique with which the refractive index and the oscillator strength of the absorption can be determined near the absorption bands of vapors (e.g., lithium, mercury, and sodium).

Surface electromagnetic (SEM) waves are transverse waves that propagate along the interface of two media with amplitudes that decay exponentially with distance from the interface into both media.

Dr. H. Talaat, while a postdoctoral fellow at the University of Pennyslvania (1975), was a member of the research team that first observed the interconversion of surface waves with volume electromagnetic waves by scattering from surface acoustic waves. In 1976, after teaching in Kuwait for a short time, Talaat joined the Optics Group at Ain Shams University and is now studying III-V materials using Raman scattering techniques. Having recently received an argon ion laser and a double grating monochromator made specifically for Raman studies, Talaat has one of the better equipped laboratories in Cairo.

Dr. M.K. El-Mously, the leader of the Solid State Group, has been studying both pure and doped selenium (Se) and Se compounds and alloys since commencing his graduate work. He has measured the electrical and thermal properties of these materials in both the amorphous and crystalline phases. In his most recent work, performed at the International Centre for Theoretical Physics (Trieste, Italy), El-Mously determined the optical absorption edge in amorphous thin films of Se and Se doped with sulphur (S). The absorption edge for pure Se was found to be close to 1.6 eV and increased with increasing S content. In a film composed of $SSe_{2.5}$, the absorption edge had shifted to 1.7 eV.

Dr. M.M. Ezzo has recently investigated the nature of the defects in slightly-nonstoichiometric TiO_x (5 samples with x ranging from 1.9970 to 2.000). Transmission electron microscopy was used to determine the type and density of defects. There has been some controversy over whether the point-defect model or the crystallographic-shear model is the more appropriate. The main observations/conclusions of this experimental study are that crystallographic-shear planes do not exist in nondeformed crystals that have been quenched (100°/min) from 1275 K, and that the production of crystallographic and mechanical deformation has a very strong influence on the production of crystallographic-shear structures.

Al-Azhar University

Dr. Taha El-Nasr is acting chairman of the men's Physics Department of Al-Azhar University, which is located in Nasr City, a suburb in the southwest part of Cairo. A typical graduating class at the BS level has 12 physics majors; currently there are also 25 MS and 15 PhD students. Graduate studies are pursued in 8 areas: Mössbauer effect, biophysics, glass (amorphous state), thin films, spectroscopy, plasma physics, thermal properties of solids, and theoretical physics.

El-Nasr described a project in which the infrared emission and transmission characteristics of wool ash were measured as a function of temperature (120° to 250°C). One objective was to determine the effectiveness of this material as a thermal shield. Two sets of measurements were made over the range of 1,000 1,000 cm^{-1} to 3,300 cm^{-1}, one in vacuum and the other in air. Absorption bands due to C-O, N-H, and C-H stretch modes were observed and the absorption was found to decrease with increasing temperature.

Dr. M.M. El-Ockr has used ellipsometry to study thin films of In, Zn, and Cd and has most recently employed the Mössbauer effect to study alloy softening in some iron solid solutions.

Two mechanisms have been proposed to explain the alloy softening that is observed in dilute alloys of iron and other bcc metals. One mechanism suggests that the variation of the stress required to overcome the intrinsic resistance of the crystal lattice to dislocation movements is caused by the addition of impurity atoms. The other mechanism puts forth the idea that a change in the chemical bond due to the solute addition results in softening. Because the Mössbauer effect can be used to provide information on the atomic force constant of a sample, and because the atomic force constant can be related to the chemical bond, this technique was used to determine the validity of the latter mechanism. The samples studied included iron alloyed with Si, Ni or Mo with concentrations of 1 wt%, 1.5 wt%, and 3 wt% each. The measurements and analysis made by El-Ockr indicate that there is no change in the force constant with the addition of solute atoms. He thus concluded that the

softening is mainly due to dislocation movements, which are highly dependent on the impurity atoms and their concentrations.

Dr. A.M. Sanad has recently studied a number of glasses, including sodium borate, calcium alumino-borate, and quickly frozen aqueous solutions of ferrous chloride. In 1979 he published a number of papers which reported on a variety of measurements made on the above glasses; e.g., Mössbauer effect, electrical conductivity, and paramagnetic susceptibility. In one of these papers he reported on a study of the behavior of the Fe^{2+} and Fe^{3+} ions in some alkali borate glasses in which Na_2O was replaced by increasing amounts by NaCl. As the ratio Na_2O/NaCl decreased, both the Mössbauer effect and the electrical conductivity data indicated that the ratio Fe^{2+}/Fe^{3+} decreased. This illustrates the oxidizing effect of the chloride ions on the Fe^{2+} ions.

Cairo University

With more than 70,000 full-time students, Cairo University is now the largest in Egypt. Prof. L.M. El-Nadi, chairman of the Department of Physics, was my host during my visit to this university. I also visited with Dr. A.-R.M. Zaghloul of the Department of Electrical Engineering, who has contributed significantly to the development of techniques for the study of thin films.

El-Nadi, who has been working in the area of low-energy nuclear physics for a number of years, recently changed the emphasis of her research to laser physics and laser/materials interactions. In addition to her responsibilities as department head, she leads a 4-person team which uses a CO_2 TEA laser in the study of breakdown phenomena in pure and doped rare gases, of the photon drag effect in Ge, and of Tokamak wall materials. The laser was a gift from Kernforschungsanlage Jülich, FRG, one of the major nuclear research centers in Europe. This laser utilizes flowing gas and its two discharge tubes have a total length of 180 cm. It can be fired at a rate of 1 pulse/min and a peak power of 150 MW is realized in a 70-80 nsec pulse. The objective of the Tokamak wall material study is to examine the products resulting from laser vaporization of materials that have been bombarded by hydrogen ions. In the photon-drag experiments, El-Nadi's group will be looking for saturation effects in Ge that may occur at high powers. As these projects were just starting, no results were available at the time of my visit. While visiting ONR London in mid-June, Dr. Yehia Negm of the University of Alexandria Research Centre (*ESN* 34-6:300) told me that El-Nadi's group had very recently observed damage effects in Ge germanium at high irradiation power levels and that this project might be dropped.

El-Nadi, who is dedicated to the development of a strong laser effort at Cairo University, will be visiting a number of laser laboratories in the US this summer in order to observe the latest techniques and data.

A.-R.M. Zaghloul and his wife, M. Elshazly-Zaghloul, received their PhD degrees from the University of Nebraska, he in 1975 and she in 1976. Both did research in ellipsometry; during the 1975-76 academic year, he was the research coordinator of the University of Nebraska's Electrical Materials Laboratory (now called the Laboratory for Surface Investigation). Since returning to the University of Cairo in 1976, Zaghloul has been working in the areas of high-voltage gas discharge and ellipsometry. He is currently working under a US National Science Foundation grant on a three-phase project in ellipsometry. The first phase involves the development of new experimental techniques and improved data analysis methods. The second involves the verification of the results of the first phase. The last brings his two areas of research together in one experiment. The new experimental and analytical techniques will be applied to the study of high-voltage breakdown of insulators resulting from atmospheric pollution. Data will be recorded and analyzed for flat electrodes in a high-voltage discharge tube, with the objective of determining the changes in surface parameters induced by ion bombardment.

A HeNe laser capable of operating on the major lines (0.633, 1.15 or 3.39 μm) will be used in the near future with the new ellipsometers. To provide a continuously tunable source for future studies, he plans to purchase an argon-ion pumped dye laser.

Tanta University

Tanta is located north of Cairo in the fertile delta of the Nile. Tanta University was founded in 1972 from the Tanta branch of the University of Alexandria and has an enrollment of more than 2?,000 full-time students. The highest degree awarded is the MS.

Prof. G.E. Hassan, head of the Physics Department and formerly active in atomic spectroscopy, introduced me to 3 of his staff: Drs. N.M. El-Siragy, F.M. El-Mekamey and B.Y. El-Baradie. He is a theoretical plasma physicist working primarily in plasma instabilities. Since 1969 he has produced 36 publications (30 abroad) on such topics as nonlinear-mode-mode coupling, plasma heating, and weak-turbulence theory. One of his students will be working on the nonlinear coupling of two surface electromagnetic waves and another on the effect of

an external magnetic field on the nonlinear interaction of intense electromagnetic waves in a plasma. El-Siragy also plans to study the changes in the optical, electrical and mechanical properties of polymers (e.g., PVC) induced by electron injection.

El-Mekamey designed and built a 1 W argon-ion laser as a graduate student in Moscow and used this laser to study the temperature dependence of the vibrational spectrum of Rayleigh scattering of solutions. At Tanta he plans to investigate the angular dependence of Rayleigh scattering in solutions—first with silver nitrate.

El-Baradie studied the statistics of laser-beam modulation while pursuing his PhD in the USSR. He studied both square and sinusoidal modulation using mechanical and electroptic modulators. He plans to build a holography laboratory at Tanta and to use holography as a tool to study the density of plasmas and stress in materials.

Mansoura University

Mansoura University is similar in many respects to Tanta University. Both are located in the Nile delta, both were founded in 1972, both have close to 27,000 full-time students, and both were formerly branches of larger institutions. Mansoura was a branch of Cairo University and Tanta a branch of the University of Alexandria. At Mansoura both MS and PhD degrees can be awarded. Twenty students have received their MS degrees in physics and the first PhD in physics is to be awarded soon. The head of the Physics Department, Prof. S.F. Nassar, has a staff of 20. Most of the remainder of this article describes a number of research projects discussed with me by the staff members.

Dr. A.M. Fouda is studying the properties of a wide range of fibers, from camel hair to multiply clad plastic fibers. He has developed a new technique for determining the thickness of the individual layers of multiply clad fibers. At Mansoura, he directs two PhD students in two projects areas: The fiber study mentioned above, and a laser/materials interaction study. In the latter project, the effects of irradiating a wide variety of metals in the form of thin films with a Q-switched ruby laser are being determined. Included among the metals are Ag, Al, Cr, Cu, Ni and Sb. The main variables observed are the reflectivity, thermal conductivity, and incident-power density. Scanning electron microscopy and interferometry are the "tools" used for the characterization of the films—before and after irradiation. Fouda is collaborating with Dr. F. Sharaf of the Military Research Centre in this new program.

Dr. Anwar Megahed has studied the thermal properties (thermal conductivity, thermal diffusion and heat capacity) of a wide range of single-crystal materials at high temperatures. Among the materials studied were ZrO, MgO, Al_2O_3, quartz and graphite at temperatures from 1000 K to the melting point of each material.

Dr. M. Abd-Rabo has concentrated on metallurgy and has been investigating the effects of heat treatment on the hardness of Al alloyed with Na and/or P, using x-ray diffraction and optical and electron microscopy in the characterization of samples. His future research will include the study of alloys of Al, Cu, Mg, Si, Sn and Sb.

In a rather unusual project Abd-Rabo uses electron microscopy and x-ray diffraction to study kidney stones removed from both affluent and impoverished patients. He mentioned that there are at least 13 factors that govern the formation of kidney stones; 3 of these are the ph in the stomach, the diet, and the length of time in bed, i.e., in a horizontal inactive position.

Other projects within the Physics Department include: applied work toward the development of efficient domestic-heating systems using solar energy, experimental and theoretical work on cell membranes to determine the effects of drugs on membrane-surface tension and surface potential, and several solid-state projects.

I conclude this article with the following comments: At present, research in Egypt is hampered by a shortage of expensive scientific equipment. This limits not only the types of measurements that can be made but also the range of materials that can be produced. It appears that the universities are now receiving increased funding for equipment, however, so these problems may be alleviated significantly in the future. That portion of the scientific community with which I interacted was well trained and enthusiastic. I look forward to seeing an increasing number of publications resulting from the research carried out in this fascinating country. (Richard S. Hughes)

RARE EARTH PRODUCTION AND REFINING

After a recent visit to the Physics Department of the University of Birmingham I had the opportunity to tour the Centre for Materials Science, a part of the university which has some of the functions or characteristics of the library or computer center. The director, Dr. D.W. Jones, told me that the idea for the

center arose out of the interest of several academic departments in material science research. Since effective research in this field requires the use of highly specialized techniques for the preparation, fabrication, analysis, and examination of materials, a center was designed to fulfill these needs.

The center is essentially a research facility, not a department, and therefore it has no undergraduate students registered for degree work. However, the center does take in students to assist them in projects similar to thesis work. In addition, a number of graduate students work within the center, all of whom will obtain their degrees from some other academic department. There are approximately 17 staff members including technical and clerical help; five of these individuals are supported by the university as tenured staff and five are research fellows who are funded by the Science Research Council (SRC). Funding of the research positions is somewhat like that in the US; the individuals act as principal investigators on projects of finite duration.

Available within the center is a wide range of analytical facilities to include mass spectrographic, x-ray fluorescence, and transmission and scanning electron microscopic equipment. In addition, and of particular interest to me, were the crystal refinement and crystal growth facilities. These are furnished with several relatively standard zone melting furnaces as well as with equipment for solid-state electrotransport processing (SSEP), a technique which has been a significant development in purification processing. This method, which is sometimes called solid-state electrolysis (SSE), involves the passage of a direct current through a sample of material. Electrons, drifting through the material under the influence of the applied field, transfer momentum, principally to the lighter interstitial impurities, which migrate toward the anode resulting in a redistribution within the sample of these impurities. Except for supports and current leads the process is containerless, and as a result the possibility of contamination is reduced. An additional advantage of the method is that large single crystals are often produced in the mid portion of the sample. For gadolinium a current of 350 A in a 5 mm diameter rod results in a temperature of 1100°C, about 100°C below the hcp-bcc transformation temperature. Continued operation for 1000 hrs in a vacuum of 10^{-5} torr produces samples whose residual resistance ratio lies between 100 and 1000.

For successful operation over a long period of time, the material undergoing SSEP must have a low vapor pressure ($<10^{-5}$ torr at approximately eight tenths of the melting temperature). For this reason, only certain rare earths (Y, La, Ce, Pr, Nd, Gd, and Tb) are suitable for SSEP in a high vacuum, although others (Sc, Dy, Ho, Er) may be processed in a sufficiently clean inert atmosphere that suppresses volatilization.

Another method employed at the center for refining high vapor pressure materials is sublimation in which the material to be refined is held in a conducting refractory metal pot of tantalum. The pot is covered with a tantalum lid, and the assembly is RF heated in a vacuum chamber. The material to be purified sublimes and in turn condenses on the cooler tantalum cover. As the process continues, purified deposits not unlike stalactites grow down from the top leaving the impurities in the bottom of the pot. With both methods the rate at which high-purity material is processed is low; for SSEP, the rate is $\sim$ 10 g per month, while for the sublimation method it is measured in grams per hour.

All of the rare earth refining performed at the center is sponsored by contracts from the SRC. The center supplies most of the rare earth samples used by research workers in the UK (*ESN* 34-7:355 [1980]). The work is carried out with the knowledge of and sometimes in cooperation with the Ames Laboratory at Iowa State University, Ames, IA.

The day following my tour of the center I visited Rare Earth Products, Limited, in the industrial city of Widnes, near Liverpool. This small company, which is the source of the rare earths purified by the center is a division of Johnson Matthey Chemicals, Limited. The general manager of Rare Earth Products, Ltd., Kenneth E. Davies, told me that the company was established in 1967 to utilize the manufacturing processes developed by Johnson Matthey for the separation of the rare earths. One of the two buildings in which the firm is housed is filled with ion exchange columns, muffle furnaces and several small vacumn furnaces; the other contains several large vacuum furnaces as well as offices.

The vertical ion exchange columns are approximately 4.5 m (15 ft) high with diameters varying between 9.1 cm and 45.7 cm (4 and 18 inches.) The columns are filled with ion exchange resin similar to that used in water purification. The material that is to be separated, which consists of mixed oxides of the rare earths, is dissolved in hydrochloric acid and run through the columns. The rare earth ions attach to the resin, forming bonds of different strength. Because of these varying bond strengths, different amounts of time are required for

the process to be completed for each rare earth. At the end of each day oxalic acid is run through each column to wash out the rare earth ions and to form a precipitate which can then be filtered and fired, resulting in a daily run of approximately 325 g of rare earth oxide R_2O_3 from each 9.1 cm (4 in) column. The oxide from each column is placed in a separate plastic bag. Chemical analysis of the oxide in each bag shows that the purity of the oxide varies with the columns; the median figure is about six 9's (99.9999%) rare earth oxides.

After standard wet chemistry processing have been performed on the contents of each bag to remove lead and iron impurities, the oxides are ready for sale or for further processing to produce the metal. This processing is accomplished by reacting the oxide with hydrogen fluoride and then firing the resulting rare earth fluorides to remove the water. After the anhydrous rare earth fluoride has been mixed with metallic calcium in a crucible of tanalium or tungsten, the crucible is heated to approximately 1100°C in argon at a pressure of approximately 1/2 atmosphere. Both the correct heating temperature and time are matters of experience; at the appropriate moment the melt is cast into a refractory metal mold. The bottom third of the casting that results contains the desired metal. Depending on the vapor pressure of the rare earth metal, this casting may be remelted in a vacuum ($\sim 10^{-4}$ torr) to produce small, irregular lumps of metal with purities of up to four 9's (99.9999%).

Mr. David Murphy, the plant manager, pointed to several holes in the concrete floor caused by fires that had occurred during processing. In his experience, Cerium and Lanthanum are the only rare earth elements that have not caught fire. The conditions for conflagration with the other rare earths are thought to depend upon either the powder size or some unknown factors. Murphy informed me, however, that shipping does not present a safety problem because the rare earth is shipped in small pieces sealed within glass ampules filled with argon. The company, which is prepared to supply rare earth in amounts from 1/2 g to 1.016 metric tons, sells both relatively pure and less highly purified material to customers all over the world.

For commercial uses, as additives in glass, ceramics, and high-strength metals, the rare earths need not be highly purified.

The company produces about 100 kg of research-grade rare earth elements and about 2.5 metric tons of higher-purity metals (95% pure or better) each year. It also produces approximately 20 metric tons of alloys per year. On most industrial bases this would represent a very modest output, but it satisfies a slowly increasing demand, and the company is operating at a profit. (John R. Neighbours)

OCEANOGRAPHY

ICEBERG UTILIZATION AND THE MENACE TO CANADIAN OIL RIGS

The Second International Conference on the Use of Icebergs was held at the Scott Polar Institute in Cambridge, England on 1-3 April 1980. The meeting was organized by the International Glaciological Society (IGS), which has its headquarters at the institute. The conference was sponsored jointly by Iceberg International Limited, Paris, France, and the King Faisal Foundation and Abdul-Aziz University of Saudi Arabia. The 23 papers that were presented are scheduled to be published in the first issue (Volume 1) of a new IGS publication, *Annals of Glaciology*.

The majority of the papers dealt with the scientific and practical feasibility of obtaining fresh water in large amounts from very large tabular icebergs originating at the edge of the Antarctic ice shelf. The remainder were on the characteristics of pack ice and icebergs in the Arctic and problems with icebergs originating in Greenland. Many of these icebergs are carried by the Labrador current southward near the coast of Newfoundland, where they are a menace not only to shipping but also to oil-drilling rigs on the continental shelf.

After introductory addresses, the scientific part of the meeting began with a very thorough assessment of the problems associated with the transport and utilization of icebergs which was presented by Dr. W.F. Weeks (US Army Cold Regions Research and Engineering Laboratory, Hanover, NH). The conclusions reached by Weeks were not challenged during the meeting.

Although ice originating in high latitudes has been transported from there by ships and used for cooling purposes in lower latitudes for over 100 years, the possible transportation and utilization of icebergs as a source of fresh water was not seriously considered until the early 1950s when Prof. John Isaacs proposed the idea for southern California. In the years following Isaacs' proposal, a number of articles on the subject were published in popular literature. It was not until 1973, however, that the idea

was taken seriously enough for interested scientists to begin to publish papers on the subject in scientific journals. The first scientific meeting on the subject did not take place until 1977. This and subsequent meetings were sparked by the interest of Prince Faisal of Saudi Arabia, the largest country in the world without a single perennial river or stream and a place where fresh water is expensive and in great demand.

Except for popular articles, the literature on the utilization of icebergs is not very extensive. Those who are interested in the subject can bring themselves up to date by reviewing the proceedings of the Cambridge conference, the proceedings of two previous conferences, and the references listed in the proceedings. (Russel, W.E. [ed.], 1980, Iceberg Dynamics Symposium, held at St. Johns Newfoundland, Cold Regions Science and Technology, 1 (3-4), 167-310; and Husseing, A.A., 1978, Iceberg Utilization, Proceedings of the first international conference held at Ames, Iowa, New York, Pergamon Press, 760 pp.)

In his presentation, Weeks concluded that the most feasible place to tow icebergs would be to the south coast of Australia (it seems to me that south and southwest Africa, where agriculture is limited by the lack of sufficient fresh water would also be likely candidates). It appears obvious that towing icebergs would be practical only if the icebergs could survive intact while under tow in the tremendous seas and swells that are almost constant features of the southern ocean in high latitudes. Although a number of papers were given on this subject, there was no consensus of opinion. It appears, however, that the best way to determine ultimately whether icebergs could survive under these conditions would be by making trials with real icebergs. We do know that large icebergs have passed through the Antarctic convergence into the warmer sub-antarctic water mass. One that was followed and observed for several days suddenly broke up into five smaller icebergs.

Aside from the problem of iceberg breakup, a number of technical problems remain.

Another problem that needs more attention is the development of cost-effective methods for docking icebergs and processing them once they have been towed to their final destination. (Only one paper was presented on this subject.) The icebergs under consideration normally have drafts of 200 m or more. Icebergs of this size being towed to southern Australia would go aground from 15 to 25 km offshore. At the very beginning of processing, the sides and bottoms of the bergs would have to be surrounded with an impermeable barrier to prevent salt water from mixing with the fresh water that is being produced. However, there would appear to be no inherent reason why the foregoing problems cannot eventually be solved.

Locating and keeping track of icebergs can be done around the clock in any kind of weather by means of satellite borne synthetic aperture radar. Selection of icebergs that are most apt to be structurally sound and least apt to break up can be done with the aid of airborne radar "echo" sounding. To begin with, fastening towing lines to Antarctic bergs would be a problem because, unless they have capsized, the top 40-60 m of bergs are composed of relatively soft snow.

Secondly, current meter records of the ocean north of the Antarctic ice shelf indicate the presence of large ring-like eddies that persist for days and are propagated downstream with the Antarctic circumpolar current. Currents counter to the direction of towing are found on one side of each ring with speeds that may be in excess of the speed with which a berg can be towed. Unless these countercurrents can be avoided, tugs with an iceberg under tow might even move backward. A great deal of research work needs to be done on the persistence, propagation, and characteristics of the ring-like eddies.

Unfortunately, with present technology, the problems of towing icebergs across the equator to regions where they would be of most value, such as Saudi Arabia and California, previously mentioned, appear to be insurmountable. The simple fact that they would have to be towed more than 5,000 km in waters with temperatures in excess of 20°C means that they would melt before they arrived at their destination unless they were completely insulated against the warm sea water. The sizes of individual icebergs are a significant fraction of a cubic kilometer. The problem of encapsulating such a huge free floating mass and keeping the insulation intact for more than 100 days would seem to be insurmountable.

Weeks also addressed the potential environmental impacts of utilizing icebergs as a source of fresh water. He concluded that none of the impacts would present serious problems. An estimated volume of 1,000 km^3 of icebergs are produced in Antarctica each year. At most, only a few percent would be harvested, and the water mass and salt balance of the ocean should not be materially disturbed. While the local atmospheric cooling that would take place in processing areas would create some fog or low clouds, this cooling should be an advantage in warm areas. In addition,

fresh water that was lost during the processing should mix rapidly with surrounding sea water with minimal effects on local flora and fauna.

Weeks mentioned several schemes for using the cooling associated with melting the ice either to generate power or to act as a heat sink for power generating systems, such as nuclear reactors, that generate large quantities of waste heat.

Dr. Olav Orheim, Norsk Polarinstitutt, Olso, presented two papers on research results from the Norwegian Antarctic Expedition of the Antarctic summer of 1978-79. The principal purpose of the cruise was to carry out geophysical measurements. Orheim and his assistants were able to study icebergs by flying to them in a helicopter. He installed an instrumented platform on one iceberg for three months and recorded typical surface strain periods between 20 and 30 seconds. Other researchers at the meeting had calculated the natural resonance period of typical kilometer-long tabular icebergs to be a about 30 seconds. Fortunately there is a relatively small amount of energy in the sea and swell spectrum above 20 seconds.

Orheim also discussed the physical characteristics and life expectancy of tabular Antarctic icebergs. He landed on 24 icebergs and studied many more from the air at latitudes between 54° and 78° S. He observed that icebergs were destroyed by breakup into smaller icebergs through calving, by melting, and erosion by sea water. The rate of dissolution increases rapidly with decreasing latitude. Breakup is caused by internal stresses due to swell and differential melting. As the temperature of the icebergs approaches 0°C cracks can no longer be refrozen and they soon break up.

Two researchers from Cambridge University of England, Dr. D.J. Goodman, Cavendish Laboratory, and Dr. P. Wadhams, Scott Polar Institute, duplicated some of Orheim's measurements on a smaller, thinner ice island (iceberg) located in a fjord on the east coast of Greenland. They found that the ice island responded to the sea swell, as measured by a gauge, by flexing at periods of above 16 seconds.

Dr. A. Foldvick, Geophysical Institute, University of Bergen, gave three papers based on the observation of his team during the Norwegian Antarctic Expedition of 1978-79. Direct measurements of oscillations were made on 15 icebergs. Flexure measurements were also made by using a theodolite to measure the relative movement of the tops of two stakes. The accuracy of the system was 1 mm in 1 km. Flexures greater than this were not observed.

In a second paper he discussed temperature measurements made with an airborne radiation thermometer at a height of only 10 m over the icebergs. All of the icebergs were embedded in water with temperatures generally below 0°C. The observed temperature anomalies in the water were relatively small, $\sim$ 1°C. The temperature of the ice-covered icebergs was very constant with variations of the order of 0.2°C with slight increases in temperature over crevasses.

In a third experiment drogues were used to measure flow around icebergs to a depth of 100 m. Tracking was done with a helicopter and a Motorola positioning system. The 0-20 m flow was wind induced. At greater depths there was little relative motion, a few cm/sec, between the iceberg and the surrounding water.

Yet another paper on the results of the Norwegian 1978-79 expedition was given by Dr. John O. Klepsuik, Continental Shelf Institute, Trondheim, Norway. He reported on the use of side-scanning sonar to study the underwater topography of large icebergs The depth of the icebergs can be accurately measured and some idea of the underwater shape of the sides of icebergs can be seen. In particular the presence and size of underwater bulges that are dangerous to ships can be determined.

Dr. David De Marle, Rochester Institute of Technology, Rochester, NY, reported on a feasibility study that he was making on the processing of icebergs into fresh water near Saldahana Bay on the west coast of South Africa, about 100 miles north of Capetown. This is a region in great need of more water for further development. The icebergs would first be anchored 50 km offshore. The sides would then be shrouded to keep fresh melt water from mixing with sea water. He suggested three possible ways of extracting the fresh water from the icebergs. The first, would be to let the ocean currents flow by the iceberg and melt it. The fresh water would then be pumped ashore as it formed inside the shroud around the iceberg. In this area of upwelling of cold 10°C water, De Marle's calculations show that a typical iceberg would produce an average of 300,000 m^3 of water a day and the average big iceberg would last the better part of a year. (The problems of keeping an iceberg anchored and shrouded for a long period of time are enormous.)

The second alternative would be to shroud the icebergs and then break them up into pieces small enough to be pumped ashore as a slurry. Once the slurry is ashore, two alternatives exist. A salty coastal lagoon could be dammed off from the ocean and pumped dry. The slurry could could be stored in the lagoon until it

melted. A more complicated process would have to be used if the bottom of the lagoon were permeable. A small impermeable basin would be used to melt the ice slurry. A heat exchanger would be used to utilize the sun-warmed waters of the lagoon to melt the slurry.

De Marle brought up one problem which was not touched on by anyone else at the conference. Icebergs contain some sea salt that has seeped into cracks and crevasses and frozen *in situ*. Thus, desalination would be necessary. He pointed out that relatively inexpensive membrane processes could be utilized on water with low salt content.

De Marle seemed to feel that iceberg utilization as a source of fresh water is possible and he is even patenting some of his engineering ideas.

A very practical paper was presented by V.I. Morgon, Antarctic Division, 569 Dt. Kilda Road, Melbourne, Australia. He and his associates, Dr. W.F. Budd and T.H. Jacka have made statistical studies of icebergs south of Australia. Data from Antarctic resupply ships and the annual Australian National Antarctic Research Expeditions (ANARE) were used for the study. Data included photographs, the number of icebergs per unit area from the ship's radar, and widths, heights, and shapes of icebergs. Size data allowed calculation of the average rate of change with distance as icebergs moved north. Satellite transponders were placed on icebergs and their rate of movement to the north was accurately documented. Along ship's routes detailed water temperatures were taken which, when combined with size data, would allow calculation of melt rates as a function of temperature.

Twenty years of ANARE data were used to determine how far north icebergs drift before breaking up and melting in the area south of Australia.

Some of the most interesting papers were about icebergs from Greenland that threaten oil-drilling rigs on the continental shelf off Newfoundland and that could, when grounded, scour out wellheads as well as pipelines on the bottom. Luckily, Greenland icebergs are much smaller than the large tabular Antarctic icebergs and have different characteristics. In addition, drilling companies have tugs standing by that, so far, have been able to lasso icebergs threatening the drilling rigs and to tow them laterally so that they pass by the rigs without damaging them. One color slide presented showed three drilling rigs, each with a "watchdog" tug standing by, and a fourth tug that was being used to study the icebergs in the neighborhood.

Dr. J.V. Barry (Memorial Univ. of Newfoundland, St. Johns) discussed bottom scouring by Greenland icebergs. Side-scanning sonar images of the Newfoundland continental shelf show countless scour marks dating from the present time through the Holocene epoch. Modern scour furrows average 30 m in width, 6 m in depth, and over 3 km in length. The furrows, which are located and identified with repetitive sea-floor mapping, have been found at maximum water depths of 200 m with maximum furrow depths of 13 m. Evidence of older furrows was found to depths of 275 m. No permanent solution was given for protecting producing wellheads or pipelines on the sea floor.

The many scientific studies that are taking place at the present time and the good attendance at symposia on utilization of icebergs indicate that a lot of individuals are seriously attacking the problems that have surfaced and that they have some hopes that icebergs may eventually be harvested. As things stand now, however, the D would appear to be far behind the R in the research and development of the use of icebergs. (Wayne V. Burt)

UNMANNED SUBMERSIBLES AT HERIOT-WATT UNIVERSITY, EDINBURGH

The Department of Electrical and Electronic Engineering at Heriot-Watt University (*ESN* 34-1:38 [1980]) has had a decade of experience in the design, construction, and operation of unmanned tethered submersibles. The department has almost completed a third-generation vehicle called ANGUS 003 (A Navigable General Purpose Underwater Surveyor). Each succeeding model has been larger, more powerful, and more complicated than its predecessor.

The original ANGUS was built to assist in various physical and biological studies of shelf seas such as inventorying benthic (sea-bottom) biological communities. With the advent of the North Sea oil industry in the early 1970s, however, much of ANGUS's efforts were diverted to the inspection of underwater structures such as oil-drilling platforms and sea-floor pipelines.

ANGUS 003 was scheduled to be completed and tested in summer 1980. Some of its vital statistics are: operational depth, 330 m; dimensions, l × b × h) 2.4 m × 1.45 m × 1.45 m; weight in air, 1 ton; submerged speed, 1 m/sec; total horsepower for maneuvering, 25 with 14 individual thrusters; and umbilical cord length, 600 m. It is equipped with still, motion-picture, and television cameras; compasses; a depth recorder; sector and side-scan sonar; and an onboard programmable microprocessor.

The first ANGUS (001) was lost for a period of time when its umbilical cord became tangled in a sea-bed structure. It was recovered after two months but its components were so badly corroded that it could not be used again. Other tethered submersibles have suffered similar fates. For that reason, research is underway to develop a semitetherless or tetherless satellite submersible (to be called ROVER) which will be operated in conjunction with and controlled through ANGUS 003. In the semitetherless mode, ROVER would be connected to ANGUS 003 by a disposable fiber optics bundle with a capability of, say, a 30 MHz bandwidth permitting the real-time transmission of multichannel TV, sonar, and instrumentation and control data over an interference-free channel that could be broken easily and replaced later in case of entanglement.

The alternative, a completely tetherless system, would preclude the use of real-time, high-resolution TV because of the relatively narrow band width of an acoustic link. A hybrid has been suggested that would have optical communications for normal operations and a back-up acoustic system of control in case the optical fiber system should fail.

Because of the attraction of a completely tetherless vehicle, the department is carrying out a thorough study of slow-scan, variable-resolution display TV systems that would transmit over a narrow-bandwidth, acoustic-channel link. The investigators are looking into the use of two TV sets. One would transmit an image each half minute, taking advantage of the fact that most of the things being examined do not change very rapidly. To avoid collisions, a second TV with a greatly reduced number of lines in the picture and a large reduction in the greyscale resolution would be used for navigation. It would require a much smaller time interval to transmit each picture.

The experience gained in navigating ANGUS 001 and 002 has shown that the most accurate system for keeping track of vehicle location is a long-base-line acoustic system with two transponders. The vehicle sends a signal to each transducer at different frequencies and measures the interval between the time each signal is sent and the time when the return signal is received from the transponders. When the computer has been told on which side of the base line the transducer is located, it can compute the position of the vehicle relative to the transponders to a repeatable accuracy of 1.5 m on a 1 km base line. A short base line system aboard the mother ship is much easier to work with, however, and this system has an acceptably small degradation of the accuracy of location. The ship-mounted system was scheduled to be in use beginning in summer 1980.

Fourteen propeller thrusters give ANGUS 003 six degrees of freedom. Because the many thrusters are close together, there are nonlinear reactions between them. Full-scale tank testing of the hydrodynamics and thruster interactions of ANGUS 002 were carried out in a model ship tank at the Admiralty Marine and Technology Establishment, Haslen, UK. The results of the tests formed the basis for a mathematic model of the actions and reactions of the system as a whole. The model will be used to program the on-board microprocessors to operate the thrusters in such a way that commands from a deck-mounted joystick and other controls can set and keep ANGUS 003 on the desired course, speed, and depth (or height over the bottom).

A realistic simulator displays a small image of the ANGUS 003 on a TV screen in what appears to be a three-dimensional presentation. An operator can then use ANGUS's deck controls to move the image around the screen and practice various maneuvers.

The British Oxygen Corporation (BOC), Crawley, UK, designed, built, and thoroughly tested another unmanned submersible which they planned to use for underwater inspection and survey in the offshore oil industry. It is somewhat similar to Angus 003 but has a greater depth capability (tested to 914 m). It has a seven-function manipulator. BOC combined its initials with part of the word, octopus, and came up with the name BOCTOPUS. The 1-ton prototype and its 15 tons of support gear have cost on the order of $1,000,000.

Inflation has forced BOC to retrench. The company chose to discontinue the unmanned submersible program, and the operation of the prototype BOCTOPUS was transferred to the Institute of Offshore Engineering (IOE), part of Heriot-Watt University (*ESN* 34-1:38 [1980]). Dr. Cliff Johnston, the new director of IOE, called the transfer a "marriage of convenience" but did not explain the terms. He intends to rename the vehicle and to use it for sea-bed survey work in the offshore oil area as well as for looking at the many industrial and governmental waste-dumping grounds around the UK. All the components of the vehicle except the portable BOCTOPUS winch will be containerized so that the whole package can be moved from ship to ship. Johnston plans to use one of the Department of Agriculture and Fisheries vessels that are berthed in Aberdeen, Scotland (*ESN* 34-6:293 [1980]) as a mother ship for the submersible.

Johnston will also continue to use divers for bottom survey work. IOE has a group of about 50 qualified divers, making it one of the largest and best-equipped groups of this type in the UK. Heriot-Watt, in fact, is the only university in the UK that offers a professional commercial diving course.

It was a pleasure to visit this energetic, industrially-oriented university for the second time. (Wayne V. Burt)

OPERATIONS RESEARCH

BUDAPS 80: MATHEMATICAL PROGRAMMING

As reported in *ESN* 33-10:430 (1979), DAPS, the Danish-Polish Seminar in mathematical programming, had been held in Poland in 1978, and in Denmark in 1979; when the venue for 1980 was set in Hungary, it became clear that the name would have to be changed. It was finally called BUDAPS 80—BU for Budapest—although in fact the meeting was held in Visegrad, a charming village on the bend of the Danube some 40 km north of Budapest. The organizers of the meeting were Jakob Krarup (Denmark), Stanislaw Walukiewicz (Poland), and Piroska Turchanyi (Hungary), with the last-named being responsible for the excellent local arrangements. The meeting was attended by 7 Danes and 6 Poles, all veterans of the previous meetings, as well as by 4 West Germans, 1 Briton, 1 Dutchman, 2 Swiss, and 1 American (myself), all of whom presented papers. In addition, there was a large Hungarian delegation, most of whom were only listeners.

The language of the conference was of course English. Virtually all of the attendees spoke English well and many of them spoke it remarkably well. In a few cases, while there was a detectable accent, one could only stand in open-mouthed admiration at the choice of words, the easy flow of prose, and the sophisticated plays on words. For example, Dominique de Werra (Ecole Polytechnique Federale, Lausanne) gave a paper entitled Beautiful Coloring Device for Edges of Finite Graphs, or the ABC of Painting Theory." It is clear that it is more than the ABC—rather it is the ABCDEFG. He opened his remarks by stating that he was going to discuss linear multiconstrained nonfractional optimization problems which added LMNOP (he had to stretch a bit to coin "nonfractional" to mean integer).

De Werra's paper came in a session devoted to graph coloring. A graph is a network consisting of nodes (or vertices) and arcs (or edges) connecting the nodes. It is well known that a wide variety of combinatorial problems can be shown to be equivalent to problems of "coloring" graphs; that is, the problem of finding the minimum number of colors such that each node of the graph can be colored differently from any node connected to it by an arc. De Werra spoke about coloring the arcs rather than the nodes, which can represent a wide variety of problems of optimally assigning time, space, or carrier units to groups of objects where some pairs of objects are mutually incompatible. For example, tasks may be assigned to working groups, to time periods, or to machines, with certain machines incapable of taking on certain jobs. The objective in such problems would usually be to minimize the number of groups, periods, or machines utilized. De Werra defined an "equitable coloring" as one in which the number of arcs of any one color never exceeds the number of arcs of another color incident on the same node by more than one. Thus, if there are 3 red arcs connected to a particular node, there may be 2 or 3 or 4 blue arcs, but no other number of blue arcs, connected to that same node. He showed that deriving an equitable coloring for a graph was equivalent to solving a scheduling problem with uniform use of resources. While he pretended not to talk about applications, he did indeed mention a number of fascinating ones, including graph-coloring problems equivalent to the optimal design of a university examination schedule, given a limited amount of time and a limited number of rooms into which the examinations may be scheduled.

In the same session László Béla Kovács of the Computer and Automation Institute in Budapest (*ESN* 34-10) reported on a new algorithm for improving graph colorings (i.e., reducing the number of colors required) by a technique called the "bichromatic interchange procedure." It was based on a systematic search for good alternating chains highly reminiscent of the Hungarian method (so called by H. Kuhn) for the assignment problem.

A new algorithm for linear programming developed by L.G. Khachyan (Computer Center, Soviet Academy Moscow) was announced last year, and has created tremendous excitement all over the world because it can be proven that the time required to execute this algorithm does not increase exponentially with the size of the problem. Such exponential increases can occur with the conventional simplex method. Calle an ellipsoidal algorithm, Khachyan's method reduces the solution space by constructing ellipsoids in a search for any feasible solution to a system of linear inequalities. In the case of a linear programming problem, a solution which is feasible for both the original problem and its dual must be an optimal solution.

E. Boros and A. Sebo (Computer and Automation Institute, Budapest) presented some changes in Kachyan's algorithm which they asserted would make it operate more efficiently. S. Walukiewicz (*ESN* 34-3:146 [1980]) presented a sophisticated analysis of the algorithm. While he shares the almost universal opinion that the algorithm as presently constituted is not likely to have practical applications or to replace the simplex algorithm, he believes that in the long term it will become practical. In particular he reported experience in applying it to certain problems (*ESN* 33-10:431 [1979]) which are known to be especially difficult for the simplex algorithm. Walukiewicz expressed interest in exchanging papers with anyone working on the ellipsoidal algorithm. His address is: Ul. Newelska 6, 01-447 Warsaw.

Klaus Schittkowski (Univ. of Würzburg, FRG) presented a remarkable paper entitled "Test and Performance Evaluation of Nonlinear Programming Codes." He is in the process of evaluating numerous different NLP codes with respect to 9 different criteria: (1) efficiency (calculation time, number of function and gradient evaluations); (2) reliability (fraction of unsuccessful solutions, together with the objective function values and the sums of constraint violations); (3) global convergence (fraction of times in which the algorithm arrives at a local optimum different from the global optimum); (4) efficiency for degenerate problems; (5) efficiency for ill-conditioned problems; (6) efficiency for indefinite problems; (7) sensitivity to slight variation of a problem; (8) sensitivity to the starting point (specifically, how the algorithm reacts when the starting point is close to and far from the final solution, in terms of the number of functions or gradient calls); (9) ease of use (quality of documentation, provision of problem data and functions, program organization, sensitivity to input parameters, and the like). The first 8 of these are all expressed quantitatively.

For this purpose Schittkowski has generated 370 new test problems; 80 of these are general problems with 4 to 20 variables and 3 to 18 constraints, and each has 3 different starting points, for a total of 240 problems. In addition there are 24 problems which are ill-conditioned , 24 which are indefinite, 32 which are degenerate, and 25 convex problems (again with 2 starting points each, for a total of 50). He has added to these 120 classical problems, those used by others (especially in well-known cases) to test particular algorithms. Each of 26 different algorithms was programmed and every algorithm was tested on every problem—a fantastic effort.

Schittkowski's conclusions were, not suprisingly, that no one algorithm is best under all criteria. In general, as might be expected, the older (penalty) methods such as SUMT do not look very good in these comparisions. Somewhat better are the generalized reduced gradient methods, such as the algorithms of Abadie and Lasdon. The best seem to be the quadratic-approximation methods such as those of M. Bartholemew-Biggs (Hatfield) and of M. Powell (Cambridge).

J. Krarup (*ESN* 33-10:432 [1979]) presented a paper on enumeration of feasible assignments. This is a classical type of combinatorial problem, and there seem to be a number of results in the literature going back 50 or more years; but in Krarup's opinion these results need to be gathered together in one place. Krarup presented some of these known (but obscure) results together with new results; for example, the number, T, of feasible solutions to the simple plant location problem when there are p facilities and q clients and z transport routes between facilities and clients. In the case when each client must be connected to exactly one facility, and where therefore z equals q, it has been known that:

$$T(p,q,q) = \sum_{i=1}^{p} (-1)^{p+i} \binom{p}{i} i^2$$

which is just p! times the Stirling number of the second kind. In the more general case, the result is

$$T(p,q,z) = \sum_{r,s \in w} (-1)^{p+q+r+s} \binom{p}{r}\binom{q}{s}\binom{rs}{z}$$

If each facility must be connected to exactly v clients (so that z=pv), then

$$T(p,q,pv) = \sum_{s=1}^{q} (-1)^{q+s} \binom{q}{s}\binom{s}{v}^p$$

Ignacy Kaliszewski (Systems Research Institute, Warsaw) discussed nonlinear integer programming problems, and pointed out that different sets of equations or inequalities for defining the same set of constraints (that is, different ways of defining the same solution space) have a marked effect on the ease of solution of such problems. It follows that in some cases constraint rotation may be very helpful. There are many cases in which this will not work—zero-one constraints, for example, cannot be moved in this way. At the other extreme, Kaliszewski gave an example of a linear integer problem with 4 variables and 6 constraints which took

222 simplex iterations involving 92 cuts and required 23 seconds on an IBM 370/145 computer. After the application of constraint rotation, which took 0.1 sec., the new problem was solved with one cut and 6 simplex iterations in 0.6 sec. He discussed the possibilities of applying this algorithm to general nonlinear integer problems.

As is often the case with special-purpose meetings where each of the participants is an active specialist, this was a particularly rewarding meeting. The next in this series of meetings on mathematical programming will be held in 1981 in Cologne, hosted by Ulrich Derigs (Univ. of Cologne). Again the name will have to be changed. Since this meeting in Budapest was called BUDAPS, one of the Danes suggested that the next one ought to be called COLLAPSE. We shall see. (Robert E. Machol)

OPERATIONS RESEARCH IN SPAIN, I: INDUSTRIAL AND COMMERCIAL

Operations research (OR) has never really flourished in Spain. A Spanish OR society was founded in 1962, but it did not prosper, and in 1977 it was combined with the Statistics Society to form a new Society of Statistics, Operations Research, and Informatics with some 350 members, most of whom are academics. OR is taught in the universities, and some competent research is being done in this field, field, to be described in another article next month. There are a handful of flourishing OR groups in industry: SEAT, an oil manufacturer in Barcelona; Altos Hornos Viscaya, a steel company in the Basque country; and in Madrid CEPSR (petroleum), RENFE (railway), Iberia (airline), and IBM (computers). I visited the last three of these.

IBERIA

The OR group at Iberia Airlines is headed by José Luis Gascó Catalá. In accordance with Spanish custom this indicates that his family name is Gascó, Catalá being his mother's name. He is listed in the telephone directory under G, and is addressed as Dr. Gascó. His doctorate was obtained from the University of Madrid in mathematics and since then he has worked in OR—for 4 years at RENFE, and the last 11 years at Iberia. His group consists of 6 professionals plus programmers and clerical support.

Many of the problems of Iberia are analogous to those of other airlines recently described in these pages: SAS (*ESN* 32-12:523 [1978]) and BA (*ESN* 34-7:315 [1980]), but others are unique. Iberia is a very large airline, second in Europe only to BA, and carries 18 million passengers per year; but the great bulk of its traffic is short haul (e.g., from one Spanish city to another), and it is much more difficult to make money on short flights than on long ones. Furthermore, Iberia is responsible for the operations of the various Spanish airports, even though most of the flights in and out of some of them are by other airlines. Five of these airports are very busy; namely Madrid, Barcelona, Palma de Majorca, Las Palmas, and Tenerife (one of these, Palma de Majorca, is the busiest airport in Europe in the summer). Iberia is responsible for baggage, refueling, cleaning of aircraft, and the like, not only for its own planes but for the planes of the other lines. This requires large numbers of people and excellent planning.

Integer-programming techniques have been used for optimal assignment of crews. Quantitative-scheduling techniques have been applied, based on detailed measurements of the exact amounts of time required for performing different services on different types of aircraft and the like. These applications, together with the assignment of flight crews, have been performed for the Flight Operations Division of Iberia. The OR group, which is attached at a staff level, has also worked for almost every other division of Iberia. They have done some unusual sampling studies for the Accounting Division: When a ticket has been used on several different airlines (for different legs of a trip) there must be an appropriate division of funds. Under some circumstances these divisions are calculated on the basis of a sample of tickets. The OR group has advised the Accounting Division on the size of sample which is adequate but not too costly. Sampling work has also been done for the Personnel Department in connection with quality control on such documents as overtime reports The OR group has worked for the Planning Department—for example on corporate planning. For the Commercial Department they have worked on a number of projects; for example, they did extensive simulation before the Madrid-Barcelona shuttle was opened a few years ago, and set up the schedules for that operation.

A particularly interesting example is their study of overbooking (a subject also discussed in the previously cited article on SAS). Most airlines practice overbooking. It should be noted that if one additional passenger could be booked on every Iberia flight, it would amount to an increase in revenue of millions of dollars every month. The problem is whether to accept or reject a new request for a reservation when the plane is alread booked to or beyond capacity.

There are three exceptions to the perfect correlation between reservations and seats: (1) the "no-show," who makes a reservation but does not appear; (2) the "no-record," who appears with a valid reservation although for some reason the airline was never notified of it; and (3) the "cancel," who makes a reservation and subsequently notifies the airline that he no longer wishes it. It is necessary to predict how many of each of these there will be. Iberia's OR group has found that this depends greatly on the types of passengers who have made reservations. Individuals have different probabilities of cancel or no-show than groups; direct purchasers have different probabilities than those who have purchased through travel agents; and some kinds of groups have different probabilities than others (e.g., a football team is less likely to cancel than a holiday group). Finally, the probability of cancellation depends upon the length of the interval between the reservation and the flight.

Based on all these factors the computer gives an immediate answer on a request for a reservation as to whether or not that reservation should be granted. The criterion is not one of costs but one of probability; for example, the probability must be less than 0.001 that a passenger with a confirmed reservation on a Madrid-to-New York flight which is fully booked will be denied boarding. Since not all flights are fully booked, the total number of passengers denied boarding per year is much less than 1 thousandth of 18 million passengers riding on Iberia.

RENFE

RENFE is an acronym for the Spanish National Railway Company. The Planning and Control Department of RENFE consists of 3 groups: Transport Engineering, Civil Engineering, and Quantitative Methods and Mathematical Statistics. The last-named was formerly called OR, but since all three groups now do OR the name no longer seems appropriate.

The head of this department is Juan Dominguez, who received his PhD from the Polytechnic University of Madrid in electronic engineering and who still thinks very much like an electronic engineer. He is very proud, for example, of the way they have solved the problem of scheduling locomotives. This turns out to be a traveling salesman problem, a famous and very difficult problem well known to the OR community. Part of his solution is based on concepts of information theory which he feels are better understood by electronic engineers than by OR people. Specifically, by using ideas related to minimum-redundancy coding (an information-theoretic concept), he has been able to reduce the sizes of the matrices which must be manipulated. Furthermore, his people have developed new algorithms which enable this problem to be solved very efficiently: he told me that an 80-city problem (this is the technical terminology for a problem involving an 80 × 80 matrix) can be solved on their IBM 370/158 computer in 4 to 5 minutes; a 135-city problem in 21 minutes; and a 180-city problem (the biggest they have tried) in 45 minutes. These numbers are rather startling. Dominguez told me that his algorithm is based on first applying the Hungarian method to produce a solution with numerous cycles, and then using a special subroutine which reduces the cycles one at a time. People who are interested may write to Dominguez at Centro De Calculo, RENFE, Estacion Delicias, Madrid, Spain.

Some 40% of the right-of-way of RENFE is single track. Scheduling on these tracks involves bringing a train to a place where the track is double for a short distance, and parking it while a train going in the opposite direction is allowed to pass. This obviously leads to very complicated scheduling problems. These problems have been solved by mixed-integer programming methods operated on the above computer using IBM's MPSX-MIP software. They are now trying to get computer terminals all over Spain so that operators can do their own scheduling locally using these techniques. They are also planning to have all timetables for Spanish railroads made up by the computer.

OR techniques are also being applied to civil-engineering tasks, such as determining the geometry of curves, and preparing schedules for development of right-of-way.

IBM

The International Business Machines Company has a Scientific Center located at the Autonomous University of Madrid, about 17 km from the center of the city. It has 38 people, of whom 31 are professionals. In accordance with an agreement between IBM and the university, the university provides the premises; IBM provides data-processing support for the university plus some scholarships, seminars, visiting professors, and the like. The center's head, José Luis Picón, assured me that this arrangement is not unique; a similar agreement puts an IBM Scientific Center in the Technion in Haifa, Israel. Picón took his PhD in electrical engineering at Virgina Polytechnic Institute, writing a thesis on adaptive control based on work which he did at Langley Field, VA, for NASA.

The center is divided into two departments of about equal size, one, Computer Science, headed by Pedro Armisén Padilla, and the other, Signal Processing and Image Processing, headed by Francisco Palou. Antonio Vazquez Manüiz, a statistician with a degree in agronomic engineering, who works for Armisén, told me that the Center tries to develop computer science and computer applications as well as to improve Spanish society. There seems to be outstanding competence at the Center. Outside of IBM there is comparatively little OR publication in Spain; there are only two OR journals, one of which is a journal on statistics as well as OR, while the other is published in Catalan, a language different from Spanish, which is spoken around Barcelona. Spaniards in general do not publish very much in the international OR literature. On the other hand, last year the IBM Scientific Center published 25 papers in English in international journals!

A typical project in the Computer Science Department is the development of interpreters for implementing APL (a computer language) on any type of machine. This project is carried out in cooperation with the IBM Center in San Jose, CA. I asked Armisén why the Madrid center was interested in cooperating with San Jose and was told that it was because the latter had a systems capability which was absent from the former. I then asked why the San Jose facility was interested in cooperating with the Madrid center; I assumed that this was because the Spaniards had lower salaries, but was told that in fact their salaries were higher. However, their competence apparently matches their salaries.

Another project, in cooperation with IBM, Rome, involves the development of pictorial data bases. An enormous amount of data nowadays comes in the form of images such as photos. These can be stored, resolution element by resolution element, and regenerated when desired for classical photointerpretation and the like. This takes an enormous amount of storage and computer manipulation. It may be better to do automatic pattern recognition and store the interpretations, or to clean up the pictures by enhancement, extraction, and the like, and then divide the resulting pictures into polygons and triangles whose vertices may be stored in the computer for subsequent regeneration.

Finally, they told me of a project being operated jointly with the IBM center in the Technion, for computer control of a greenhouse, where vegetables are grown hydroponically. It is necessary to control not only the climate (temperature, humidity, and carbon dioxide), but also the sunlight (closing shutters if there is too much, turning on lamps if there is not enough) and the nutrition (the nutrients in the hydropronic solutions). At this time the living plants themselves are not in the control loop, but Armisén's people are starting analysis which will relate the behavior of the plant to the environment so that actual measurements on the plant may be used to control the environment itself.

In the Image Processing and Remote Sensing Department, they have been working since 1974 on the interpretation of photographs, especially the "Landsat" photographs taken from satellites by NASA. They are in close touch with the NASA people and are not duplicating any of their research. As one example of their research, photographs are not taken exactly vertically; that is, the satellite is not exactly in the zenith of the target area. This leads to distorted coordinate systems (that is, a skewed picture) which can be rectified by the computer. Furthermore, it is necessary to compare the pictures taken by the satellite in 4 different wavelengths, and also pictures taken by the satellite of the same territory at different times. The latter involves particular complications not only because of the different skewing of coordinates, but also because of the different shadowing effects when the same target is looked at from different angles and because of the different illumination on the same area as photographed at different times of the day.

In addition to these developments of new techniques, they have performed some remarkable applications by examining the Landsat photographs of Lake Nasser (the water impounded behind the Aswan Dam in Egypt). They have been able to draw detailed topographic maps of the depth of the water throughout the lake. They are also studying the types of soil in Kuwait from Landsat photographs, in an attempt to predict (and perhaps ultimately to control) the sandstorms which are so troublesome there.

Finally, they are engaged in a detailed study of agricultural regional planning to develop a system to help regional planners in designing and evaluating different regional agricultural policies. They are working with universities in Sevilla and Córdoba as well as the National Research Council, the Ministry of Agriculture, and the IBM Scientific Center at the Technion. This regional planning study will be completed in June of 1981.

To sum up: good OR is done in only a few places in Spain, and exceptionally good OR only at the IBM Scientific Center in Madrid. (Robert E. Machol)

NEWS AND NOTES

ROBOT RESEARCH PARTNERSHIP AWARDED SCIENCE RESEARCH COUNCIL FUNDING

A $1,000,000 a year research program into robotics, to be carried out by partnerships of industrialists and university groups, was announced by the UK Science Research Council (SRC) recently.

The program, which will be coordinated by a special team based at the council's Rutherford and Appleton laboratory, will aim to supersede present ranges of robotics devices and provide research needed to ensure that Britain's industry can take full advantage of new developments.

The partnerships, which are being set up following the success of the SRC's teaching companies which link manufacturing industry and university and polytechnic groups, will form the main thrust of the council's robotics initiatives, although a few long-range proposals will be supported by normal grants.

"A firm building robots may be a suitable partner if it acts as a "window" through which the academic group may be aware of not just one, but a number of potential applications which can benefit from the proposed work" states a special SRC booklet on the scheme.

There are disadvantages, the SRC admits. "First, the council will be supporting work which, in the early stages at least, may involve relatively little basic research; and second, questions of commercial confidentiality and rights need to be considered at an early stage of drawing up a "marriage contract."

In the end it is hoped the best partnerships will become increasingly independent of SRC support and some companies may also support work through direct grants to university or polytechnic partners on a consultancy basis.

The main research areas to be covered by the robotics program will be:

(1) Sensory devices that will be capable of "ultrahigh speed" detecting of variations in tactile, visual infra-red, ultrasonic and other variables.

(2) Control and guidance techniques for mobile robots.

(3) Safety, diagnostic and error-recovery functions that will allow robots to learn from previous errors.

(4) Standard techniques for specifying and measuring performance of robotics devices. (The Times)

SCIENTISTS TOAST SATELLITE SUCCESS

Scientists of 7 European countries recently celebrated the fifth anniversary of the successful operation of the European Space Agency's first satellite, the COS-B, which was originally designed to operate for only one year. In that time, the satellite has carried out the first complete and detailed survey of the Milky Way in high energy gamma rays, providing vital information about the structure of our Galaxy. Several new gamma-ray sources were discovered in the process and the COS-B also investigated the Vela and Crab Nebula pulsars.

Now the spacecraft, which was constructed by an industrial consortium that involved seven agency member countries—Britain, Belgium, Denmark, France, Germany, Italy, and Spain—may be used to probe extra-galactic regions of space.

CHAIRS

Professor M. Akhtar has been appointed to the newly-established chair of biochemistry at the University of Southampton, UK, with effect from October 1, 1980. Akhtar, recently elected a fellow of the Royal Society, currently holds a personal chair in the university.

The University of Manchester Institute of Science and Technology (UMIST) has appointed Mr. Frank Hartley as visiting professor in polymer and fiber science. Hartley is at present senior research associate in ICI's (Imperial Chemical Industries) Organics Division based at Blackley, Manchester, UK.

OBITUARIES

Mr. Rhys Price Probert, CB, director of the Royal Aircraft Establishment (RAE), Farnborough, UK, since 1973, died on August 15. He was 59.

Probert's career spanned a formative period in the fields of aeronautics and aircraft propulsion, and culminated in his election to Fellowship of Engineering in 1978 and in his presidency of the Royal Aeronautical Society during 1979-80.

ONR COSPONSORED CONFERENCES

NATO Advanced Study Institute, "Singularities in Boundary Value Problems," Maratea, Italy, 22 September-3 October 1980.

NATO Advanced Study Institute, "Molecular Ions: Geometric and Electronic Structures," Isle of Kos, Greece, 30 September-10 October 1980.

Workshop on Producing a Scientific Plan for the Marginal Ice Zone Experimental Program, Voss, Norway, 5-8 October 1980.

International Workshop on "Ion Formation from Organic Solids," Münster, West Germany, 6-8 October 1980.

5th International Conference on Infrared and Millimeter Waves, Würzburg, West Germany, 6-10 October 1980.

European Visitors to the US, Supported by ONR London

Name of Visitor	Affiliation	Navy Lab./Org. to be Visited
	OCTOBER	
Dr. K. Allen	Adhesion Science Group, City University, London, UK	NRL, NSWC
	DECEMBER	
Dr. F. Durst	Sonderforschungsbereich 80 an der University Karlsruhe, West Germany	NRL, ONR, NOSC

ONRL REPORTS

C-8-79

Physics of Nonlinear Transport in Semiconductors
by Irving Kaufman

This is a report on the NATO Advanced Study Institute of Nonlinear Transport in Semiconductors, held at the Sogest Center near Urbino, Italy, during 16-27 July 1979. The Institute was held to "provide young researchers with the foundations of the principles of nonlinear transport," so that they might meet the challenges of nonlinear transport behavior that will be encountered in work with ultra-fine-geometry or ultra-high-speed semiconductor devices. The topics that were treated include phenomenological aspects of hot carriers, electronic structure and band renormalization, electron-phonon interactions, semi-classical and quantum transport, carrier-carrier interactions and screening, non-equilibrium phonon magentic field effects, device effects, noise and diffusion, and optical excitation of hot carriers.

C-3-80

Oceanexpo '80; Bordeaux, France by C.H. Spikes

This is a report on the 4th International Exhibition and Symposium on the exploitation of the world's oceans, covering shipbuilding, offshore techniques, harbors, fishing and pollution control, held in Bordeaux, France, 4-8 March 1980. The International Sponsoring Committee consisted of the President of the Republic of Senegal and the Chairman of the French National Assembly. Over 84 countries were represented with emphasis on the African, Caribbean and Pacific (A.C.P.) States, the Arab countries, the Southeast Asian countries and Latin America. Primarily a glittering showcase for the opulent Arabian nations, conference discussions ranged from seabed mining techniques to high seas piracy. The well-attended exhibits covered fields as diverse as aqua culture and and lightning research, while the Warsaw Pact was represented by both Poland and the USSR.